5743

GROUNDWATER REMEDY EVALUATION AND FIELD VERIFICATION PLAN

FERNALD CLOSURE PROJECT
FERNALD, OHIO

OCTOBER 2004

U.S. DEPARTMENT OF ENERGY

52460-PL-0001
REVISION 0
FINAL

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LIST OF ACRONYMS AND ABBREVIATIONS

amsl	above mean sea level
AWWT	Advanced Wastewater Treatment
CAWWT	Converted Advanced Wastewater Treatment
D&D	Demolition and Disposal
DOE	Department of Energy
EPA	U.S. Environmental Protection Agency
FRL	final remediation level
GMA	Great Miami Aquifer
gpm	gallons per minute
IAWWT	Interim Advanced Wastewater Treatment
IEMP	Integrated Environmental Monitoring Plan
ISER	Integrated Site Environmental Report
Kd	partition coefficient
L/kg	liters per kilogram
µg/L	micrograms per liter
OEPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
OU5	Operable Unit 5
ROD	Record of Decision
SER	Site Environmental Report
SPIT	South Plume Interim Treatment
SSOD	Storm Sewer Outfall Ditch
VAM3D	Variably Analysis Model in 3 Dimensions
WSA	Waste Storage Area

1.0 INTRODUCTION

This Groundwater Remedy Evaluation and Field Verification Plan evaluates two groundwater remedy approaches for the restoration of the Great Miami Aquifer (GMA) at the Fernald Site for use after modification of the Advanced Wastewater Treatment (AWWT) Facility is initiated. The two groundwater remedy approaches are: 1) A remedy without well-based reinjection, and 2) A remedy without well-based re-injection that includes induced recharge through the Storm Sewer Outfall Ditch (SSOD) at a rate of 500 gallons per minute (gpm). Field methods are outlined that will be used to verify model predictions and assess operational uncertainties associated with the approaches.

This plan fulfills two commitments made by the U.S. Department of Energy (DOE) to the U.S. Environmental Protection Agency (EPA) and Ohio Environmental Protection Agency (OEPA) in a letter dated May 5, 2004 (DOE-0247-04) concerning the benefits associated with the "carve-down" of the AWWT Facility. The two commitments were to prepare a Capture Zone Evaluation Test Plan and a Storm Sewer Outfall Ditch Re-Injection Test Plan.

Section 2 presents groundwater modeling for a groundwater remedy approach that does not contain well-based re-injection. Section 3 presents groundwater modeling for a groundwater remedy approach that has induced recharge through the SSOD. Section 4 provides a summary of modeling results and presents recommendations. Section 5 presents a field verification plan for:

- Achieving capture of the 30 micrograms per liter (μg/L) uranium plume without well-based re-injection,
- Evaluating the capability of the SSOD and its tributaries to serve as a pathway for 500 gpm of induced recharge to the GMA,
- Confirming that long-term pumping from the construction wells on the east side of the Fernald Site will not detrimentally affect plume capture; and
- Achieving capture of the 30 μg/L uranium plume without well-based re-injection but with induced recharge at 500 gpm down the SSOD and its tributaries.

1.1 BACKGROUND

With site closure in 2006, several water treatment flows will be eliminated or reduced (i.e., remediation wastewater, sanitary wastewater, storm water runoff) from the scope of the treatment operation. Elimination/reduction of these flow streams provides an opportunity to reduce the size of the water treatment facility that will remain to service the aquifer restoration after site closure. Reducing the size of the treatment facility prior to site closure in 2006 will reduce the amount of impacted materials that may need future off-site disposal. The 1,800 gpm Phase III expansion system of the AWWT will remain, but about 90 percent of the existing facility footprint will be dismantled and placed in the On-Site Disposal Facility (OSDF). The subsequent placement of the affected debris and underlying soils in the OSDF will be completed in time to meet the 2006 site closure schedule, and result in a protective, more cost effective long term water treatment facility to complete aquifer restoration.

In addition to decreasing the size of the water treatment facility, operational approaches to the aquifer remedy are also under evaluation to determine if a more efficient way of remediating the aquifer can be found. Scenarios under evaluation include:

- Stopping well-based re-injection
- Induced recharge of water through the SSOD

The current aquifer remedy design is presented as Scenario 1 in the Comprehensive Groundwater Strategy Report. Currently there are 22 extraction wells, 7 re-injection wells, and one injection pond, with plans for the installation of two more extraction wells in the Waste Storage Area (WSA-5 and WSA-6) once source removal excavations are complete in that area (see Figure 1.1).

Groundwater modeling presented in the Comprehensive Groundwater Strategy Report (DOE 2003a) predicts that continued use of large-scale re-injection using current re-injection wells would shorten the aquifer remedy by three years, (comparison of Alternatives 1 and 6). These results indicate minimal benefit to maintaining the infrastructure for large-scale well-based re-injection.

Re-Injection was shut down in September of 2004 to facilitate the "carve down" of the AWWT into the Converted AWWT (CAWWT). During CAWWT construction, groundwater treatment capacity is limited and not enough treated groundwater is available to support well-based re-injection. The decision has been made to not re-start well-based re-injection after completion of CAWWT. Instead, operations will proceed without well-based re-injection and other operational strategies to enhance the aquifer remedy will be explored, such as inducing recharge to the GMA through the SSOD. Post-CAWWT construction pumping rates will be established in a new groundwater remedy design, pending outcome of field verification activities outlined in Section 5.

In support of the decision to stop large-scale well-based re-injection, groundwater modeling was conducted to predict what would be needed to capture the 30 μg/L uranium plume without well-based re-injection. The initial plume used in the groundwater model was updated with all available monitoring data collected through 2003 in order to support this study. The first modeling run resulted in predicted capture of the 30 μg/L uranium plume. These modeling results are presented in Section 2. Additional groundwater modeling was then conducted to assess the added benefit gained by inducing recharge at a rate of 500 gpm down the SSOD. These modeling results are presented in Section 3.

Modeling results and information gathered from field verification exercises outlined in this document will be considered in a final design that will be selected as the path forward for the Aquifer Remedy. Once a final remedy design has been selected, a design document will be issued. If the outcome of the SSOD test is that induced recharge down the SSOD does not provide enough benefit to pursue, DOE will continue to evaluate other methods for improving remedy performance.

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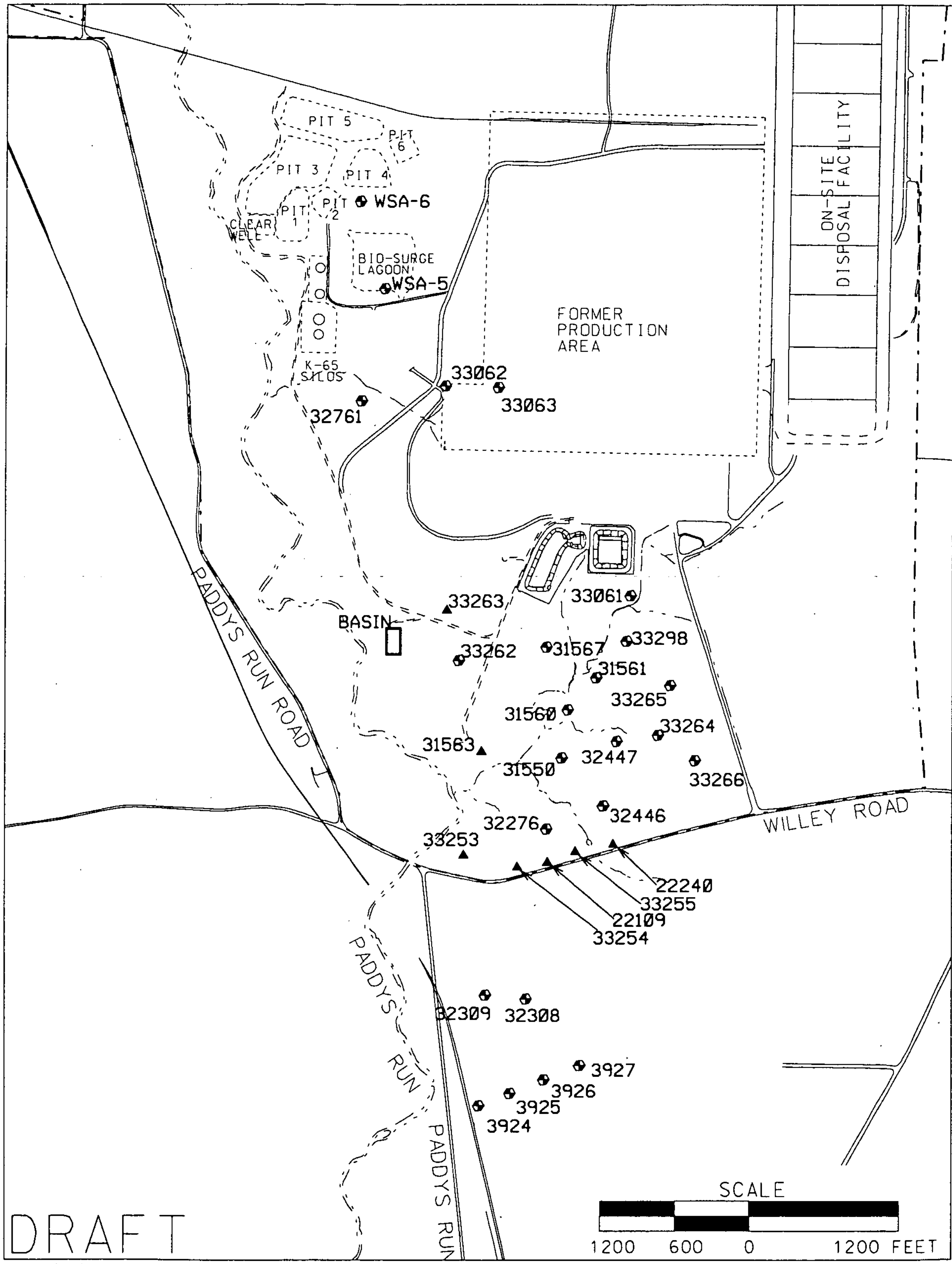

LEGEND:

—·—·— FERNALD SITE BOUNDARY

EXTRACTION WELL

▲ RE-INJECTION WELL

FIGURE 1.1. WELL LOCATION MAP

2.0 AQUIFER REMEDY WITH NO RE-INJECTION

This approach (designated Approach C) evolved from Scenario 2 of the Comprehensive Groundwater Strategy Report. For modeling purposes, Approach C was divided into five pumping rate periods, Table 2.1.1. Important modeling dates for these pumping periods are;

- 10-1-04, Begin construction of the CAWWT
- 4-1-05, Begin full-scale operation of CAWWT. CAWWT could be ready for operation as early as February 2005
- 4-1-06, Begin operation of WSA Phase II wells
- 4-1-12, Model prediction that clean-up goals reached off property.

Approach C was developed assuming a groundwater treatment capacity of 800 gpm from South Plume Interim Treatment (SPIT) and Interim AWWT (IAWWT). A treatment capacity of 1200+ gpm will initially be available from CAWWT. At site closure, the CAWWT will provide up to 1800 gpm capacity for groundwater. Although Approach C cannot serve as a final design for the remedy, it can be used to demonstrate cleanup without large-scale well-based re-injection. Post-CAWWT pumping rates will be established in a new groundwater remedy design, pending outcome of field verification activities outlined in Section 5.

2.1 FLOW MODEL RESULTS

The large Variably Analysis Model in 3 Dimensions (VAM3D) model (120 x 112 x 12) was used to set boundary conditions for the smaller zoom model. For each pumping period, the large VAM3D model was run to steady state. Steady state head values from the large model at nodes closest to the zoom model boundary nodes were assigned to the zoom model using a FORTRAN program. The zoom model was then run to steady state with the constant head boundaries derived from the larger model.

As discussed in Section 3.2 of the Conceptual Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas (DOE 2000a), the large VAM3D flow model is calibrated to an October 1998 groundwater monitoring data set (nominal aquifer conditions). Validation was done to wet and dry season data sets from July 1998 and October 1999, respectively. Nominal corresponds to the October 1998 elevation data set. An explanation of how the nominal boundary conditions were derived can be found in the Great Miami Aquifer VAM3D Flow Model Recalibration Report, which was issued in 2000 (DOE 2000b).

Predicted groundwater elevations for Approach C are shown for nominal boundary conditions in Figures 2.1.1 through 2.1.5 for each pumping time period defined in Approach C. Figures 2.1.6 through 2.1.12 show 10-year time-of-travel, non-retarded, particle paths for each pumping time period defined in Approach C. The particles in these figures were seeded in the model at the 30 μg/L uranium plume boundary at an elevation of 510 feet above mean seal level (amsl) corresponding to the elevation in the plume where the highest levels of contamination are situated. The 30 μg/L uranium plume shown in Figures 2.1.6 through 2.1.11 is the maximum uranium plume reported for the second half 2003 in the 2003 Site Environmental Report (SER, DOE 2004a). As discussed in Section 2.2, under Approach C the South Plume, south of Willey Road, will be remediated by the year 2012, at which time pumping from the South Plume Wells will end. Therefore, Figure 2.1.12 (for time period 2012 to the end of the remedy) illustrates capture using the model predicted 30 μg/L uranium plume for the year 2012. The particle path figures illustrate capture of the 30 μg/L uranium plume, at 510 feet amsl, throughout the aquifer remedy using the pumping rates defined for Approach C. Using the 2003 maximum plume definition to illustrate capture up to year 2012 is conservative in that the plume footprint will actually decrease as the cleanup proceeds. With the exception of Figures 2.1.8 and 2.1.9 all of the particle paths are run under nominal boundary conditions. Particle tracks were also run for the CAWWT construction time period for wet and dry boundary conditions in order to illustrate predicted capture under these boundary conditions as well. Figure 2.1.8 is run for the CAWWT construction time period using dry boundary conditions from October 1999. Figure 2.1.9 is run for the CAWWT construction time period using wet boundary conditions from July 1998.

Particle tracking also indicates that if the re-injection wells are turned off stagnation effects between the South Plume and South Field Extraction Wells will increase. Three additional particle path figures (Figures 2.1.13 through 2.1.15) illustrate this prediction. Particles in Figures 2.1.13 and 2.1.14 were seeded at the extraction wells and tracked backwards to determine zones of influence for each extraction well. Figure 2.1.13 illustrates capture with re-injection. It depicts 10-year time-of-travel particle paths for the groundwater remedy based on target pumping and re-injection rates for 2003. The figure illustrates that re-injection serves to help minimize the stagnation effect by flushing out the area of stagnation. Figure 2.1.14 illustrates capture without re-injection. Without re-injection the model predicts that the stagnation-effect will increases because flushing in the area from the re-injection wells is not taking place. Figure 2.1.15 provides a different view of this model prediction. Figure 2.1.15 is a 10-year, time-of-travel plot, with forward particle tracks, using pumping rates that are planned during CAWWT construction. Particles were seeded along Willey Road at an elevation of 510 feet amsl and 520 feet amsl using nominal boundary conditions. The particle tracks again show an area of stagnation between the South Field and South Plume Extraction Wells.

2.2 TRANSPORT MODEL RESULTS

The VAM3D transport model was run to estimate how the Approach C Design would perform given the observed aquifer concentrations (initial conditions) and the contaminant source terms remaining. Transport runs were made with nominal boundary conditions. A constant partition coefficient (Kd) of 3.0 liters per kilogram (L/kg) was used for all transport runs. A Kd of 3 L/kg was also used in the Comprehensive Groundwater Strategy Report. Additional information concerning the use of a Kd of 3 L/kg is provided in the Comprehensive Groundwater Strategy Report.

2.2.1 Initial Conditions

The transport model was run with initial conditions for total uranium developed from Kriged monitoring data. As part of a continuing effort to improve transport predictions of wellhead concentrations, and in response to recent informal comments from EPA and OEPA regarding transport model calibration, initial conditions in the transport model were updated using data collected through December 31, 2003 (2003 data set). Initial conditions used in the transport model for the Groundwater Strategy Report only used data collected through December 31, 2002 (2002 data set). A comparison of initial conditions modeled using the 2002 data set (updated to December 2003 with one year of modeling) to initial conditions using the 2003 data set is provided in Figure 2.2.1, which illustrates the general agreement of plume geometry between the two data sets. Initial conditions derived from the 2003 data set show higher uranium concentrations than initial conditions derived from the 2002 data set, as detailed below.

For the 2003 data set, observed versus predicted wellhead concentrations were compared using plots of concentration versus time. These concentrations versus time plots were presented in Attachment A.1 of the 2003 Integrated Site Environmental Report (ISER, DOE 2004b). Observed wellhead concentrations are based on the average concentration data collected from monitoring wells in 2003 and concentration data collected from direct push-sampling locations from 1996 through 2003. When newer direct-push sampling data overlapped with older data at the same location, the newer data were used. Multiple direct-push sampling data were not collected from the same location in 2003. The process of replacing older geoprobe data with newer geoprobe data has and will continue to take place. Only four of the direct-push data locations used in the 2003 data set predate the active remediation. (i.e., completed before 1998). These four locations (Locations 12196, 12197, 12265, and 12235) are shown in Figure A.2-3A of the 2003 Integrated Environmental Monitoring Plan (IEMP, DOE 2003b).

The spatial statistics of the 2003 data set were different from those of earlier data sets. Horizontal and vertical ranges on the semi-variograms were 300 feet and 20 feet, respectively; compared to ranges from 500 to 700 feet horizontally and 50 to 70 feet vertically that were observed in earlier data sets. This smaller range in the 2003 data set is due to more closely spaced data with increased vertical resolution from the use of more direct push data.

With smaller horizontal and vertical ranges in the 2003 data set, the horizontal Kriging radius used to develop initial conditions was set at 300 feet with a vertical Kriging radius of 20 feet (horizontal to vertical anisotropy ratio of 15). Consequently, the 2003 initial condition plume has less vertical smearing of the plume with depth and higher concentrations around data "hot spots", relative to the 2002 initial conditions. For example, the maximum concentration in the initial condition file developed from the 2002 data set was 481 μg/L in Model Layer 12, while the maximum concentration was 591 μg/L in Model Layer 12 using the 2003 data set. The increase is a result of: 1) higher uranium concentrations being measured in some of the Type-8 monitoring wells, 2) a change in the spatial statistics inherent in the data (i.e., more densely grouped data), and 3) the result of a smaller Kriging radius used in the 2003 data set. Figures 2.2.2 and 2.2.3 show the horizontal and vertical semi-variograms for the 2003 data set.

The total dissolved and sorbed mass in the 2002 initial conditions data set was 762 pounds and 5,335 pounds, respectively; compared to 641 pounds dissolved mass and 4,491 pounds sorbed mass in the 2003 initial conditions data set (assuming a Kd of 3.0 L/kg). Total mass was 6,097 pounds in 2002 and 5,132 pounds in 2003, a difference of 965 pounds. This value compares favorably with the 1,162 pounds of total uranium removed from the aquifer by pumping during 2003. Kriging results used as initial conditions for the zoom model are shown in Figures 2.2.4 through 2.2.7 for Model Layers 9 through 12.

Wellhead concentrations predicted from VAM3D transport runs are in closer agreement to observed concentrations when the 2003 data set is used for initial conditions and when the data is Kriged with smaller horizontal and vertical ranges. Model predicted concentrations more closely matched observed concentrations when initial conditions in the model were developed using the average monitoring well concentration from 2003 rather than using the maximum well concentration measured in 2003. Initial conditions developed with the 2002 data set used the maximum concentration from each monitoring location. An unexpected benefit from the 2003 evaluation and updating of initial conditions is a reduction in predicted clean up times by approximately four to five years, relative to modeling results presented in the Comprehensive Groundwater Strategy Report.

2.2.2 Transport Model Source Terms

Operable Unit 5 (OU5) Remedial Investigation/Feasibility Study (DOE 1995a and 1995b) source terms that correspond to sources in the SSOD and Waste Pits Project were retained in the model through year 2006. After 2006, these source terms were removed to reflect the complete remediation of all contaminated material at the Fernald Site.

2.2.3 Predicted Total Uranium Concentrations

Figures 2.2.8 through 2.2.16 show predicted total uranium concentrations in zoom Model Layers 11 and 12 at the end of each pumping period, under nominal flow boundary conditions. Concentrations are shown in zoom Model Layers 11 and 12 because these two layers contain most of the > 30 μg/L uranium plume. As seen in Figure 2.2.16, the total uranium concentrations in the aquifer are below 30 μg/L in 2020, except in a small area near the Pilot Plant Drainage Ditch. Total uranium concentrations in this area drop below 30 μg/L between 2022 and 2023.

2.2.4 Ability to Meet Discharge Limits at the Parshall Flume

The ability to meet discharge limits at the Parshall Flume was assessed using "Test Pump". Test Pump is an excel spreadsheet that calculates a flow weighted discharge concentration, based on pre-defined treatment capabilities, extraction well uranium concentrations, and pumping rates. Groundwater treatment capacity will be limited to 700 gpm during the CAWWT construction time period. If discharge limits can be met during this time period then discharge limits will be met during the subsequent pumping periods when 1200 gpm are available for groundwater treatment. Table 5.1 illustrates that the discharge limits can be met during the CAWWT construction time period. The blended outfall concentration is predicted to be 26 μg/L and the mass of uranium per year to the river is predicted to be 589 pounds.

2.3 APPROACH C MODELING CONCLUSIONS

Modeling results indicate that the discharge limits in the OU5 Record of Decision (ROD, DOE 1996) can be met with pumping rates defined for Approach C. The OU5 ROD refers to a modeling scenario based on 28 wells operating 27 years, at a combined maximum pumping rate of 4000 gpm. Pumping rates for Approach C are presented in Table 2.1.1. The lowest net extraction rate for Approach C is 4,275 gpm.

Particle path figures predict capture of the 30 μg/L uranium plume throughout the life of the aquifer remedy using the pumping rates defined for Approach C. These results are considered conservative in that Approach C only provides for 800 gpm groundwater treatment and up to 1800 gpm will actually be available. This means that higher pumping rates could actually be achieved, which should increase capture and reduce clean up times.

Without re-injection along Willey Road, pumping from the South Field Extraction Wells competes for water with the South Plume Optimization Wells creating an area of stagnation along Willey Road. The particle tracks indicate that once large-scale well-based re-injection is discontinued, more attention will need to be given to the area along Willey Road in order to disrupt the stagnation zone as much as possible through actions like pulsed pumping. Evaluation of this stagnation zone area will be limited due to it being under private property and in an area with very few existing monitoring wells. When re-injection is turned off, direct-push sampling should be conducted periodically to assess remediation progress in the area where the stagnation zone is predicted. Additional monitoring wells should also be installed, if landowner permission can be obtained. Direct-push sampling and monitoring of any additional monitoring wells should be handled through the IEMP specified Remedy Performance Monitoring.

Modeled aquifer cleanup for Approach C occurs between 2022 and 2023.

Direct comparison of modeling results from Approach C to modeling results presented in the Comprehensive Groundwater Strategy Report should take into consideration that initial conditions and Kriging used for Approach C have changed from what was used in the Comprehensive Groundwater Strategy Report (see discussion in Section 2.2.1).

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Table 2.1.1
Pumping Rates for Approach C

	Pumping Periods				
	1 1/1/04 to 10/1/04 (gpm)	2 10/1/04 to 4/1/05 (gpm)	3 4/1/05 to 4/1/06 (gpm)	4 4/1/06 to 4/1/12 (gpm)	5 4/1/12 to End (gpm)
SP 1 (3924)	300	300	200	200	0
SP 2 (3925)	300	300	200	200	0
SP 3 (3926)	300	300	200	200	0
SP 4 (3927)	400	400	200	200	0
SP Opt 6	300	300	200	200	0
SP Opt 7	300	300	200	200	0
Sub Total	1900	1900	1200	1200	0
SF 17	275	275	175	175	175
SF 18	200	200	100	100	100
SF 19	200	200	100	100	100
SF 20	200	200	100	100	400
SF 21	290	100	200	200	300
SF 22	300	300	300	300	400
SF 23	300	300	300	300	400
SF 24	300	100	300	300	300
SF 25	300	300	100	100	100
SF 31	200	100	200	200	300
SF 32	300	100	200	200	400
SF 33	300	300	300	300	400
SF 34	200	200	200	200	200
Sub Total	3365	2675	2575	2575	3575
WSA 1	300	0	300	300	500
WSA 2	400	0	200	200	200
WSA 4	0	0	0	200	200
WSA 5	0	0	0	100	100
WSA 6	0	0	0	100	100
Sub Total	700	0	500	900	1100
Total Extraction	5965	4575	4275	4675	4675
IW 8A	200	0	0	0	0
IW 9A	200	0	0	0	0
IW 10	200	0	0	0	0
IW 10A	200	0	0	0	0
IW 11	200	0	0	0	0
SF 16	200	0	0	0	0
SF INJ 1	100	0	0	0	0
BASINS	100	0	0	0	0
SSOD	0	0	0	0	0
Total Re-injection	1400	0	0	0	0
Net Extraction	4565	4575	4275	4675	4675

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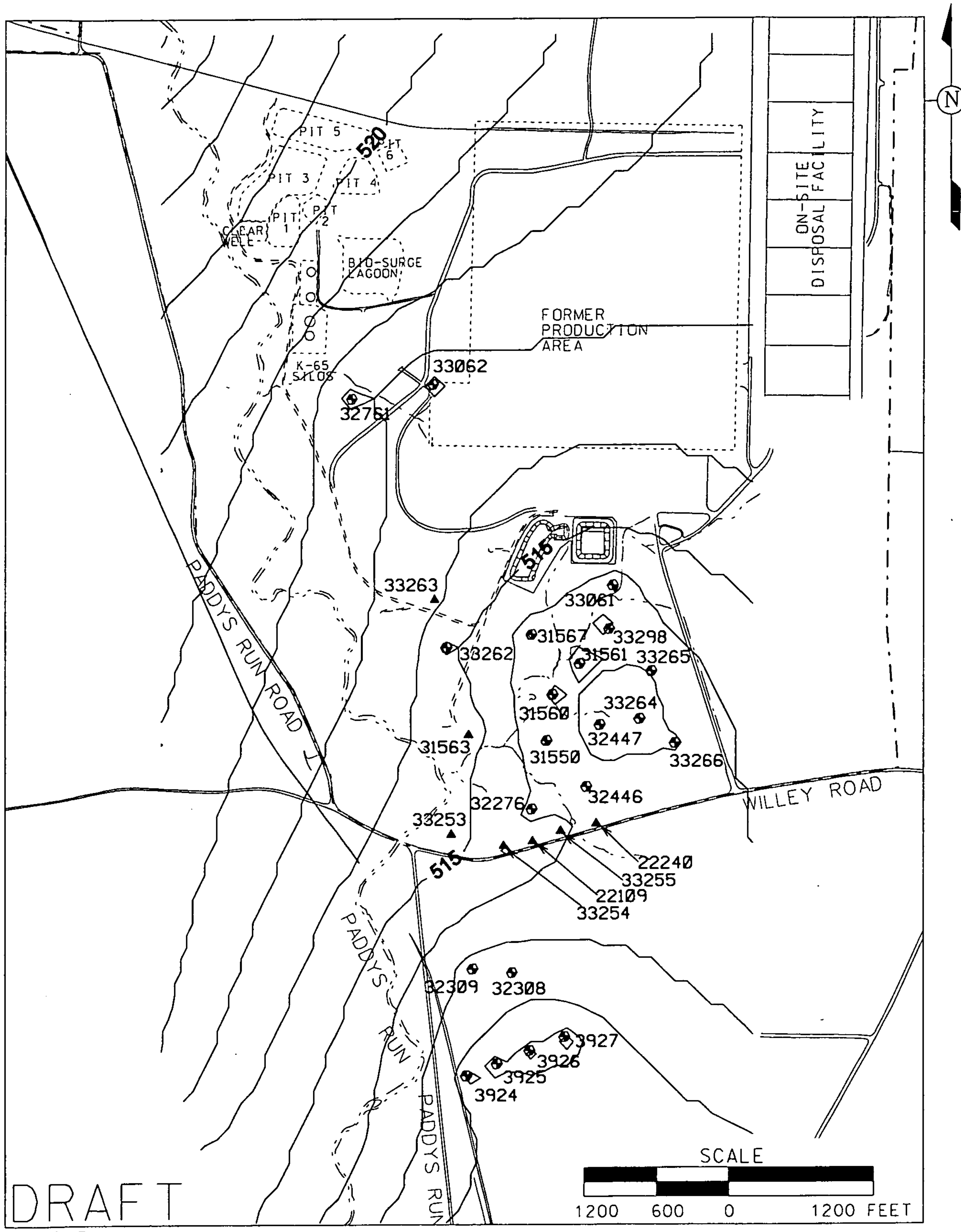

STATE PLANAR COORDINATE SYSTEM 1983

22-JUN-2004

LEGEND:

- —·—·— FERNALD SITE BOUNDARY
- ——— GROUNDWATER ELEVATION CONTOUR
- ⊕ EXTRACTION WELL
- ▲ INJECTION WELL

FIGURE 2.1.1. MODELED GROUNDWATER ELEVATION PREDICTIONS, CURRENT TO 10-1-2004

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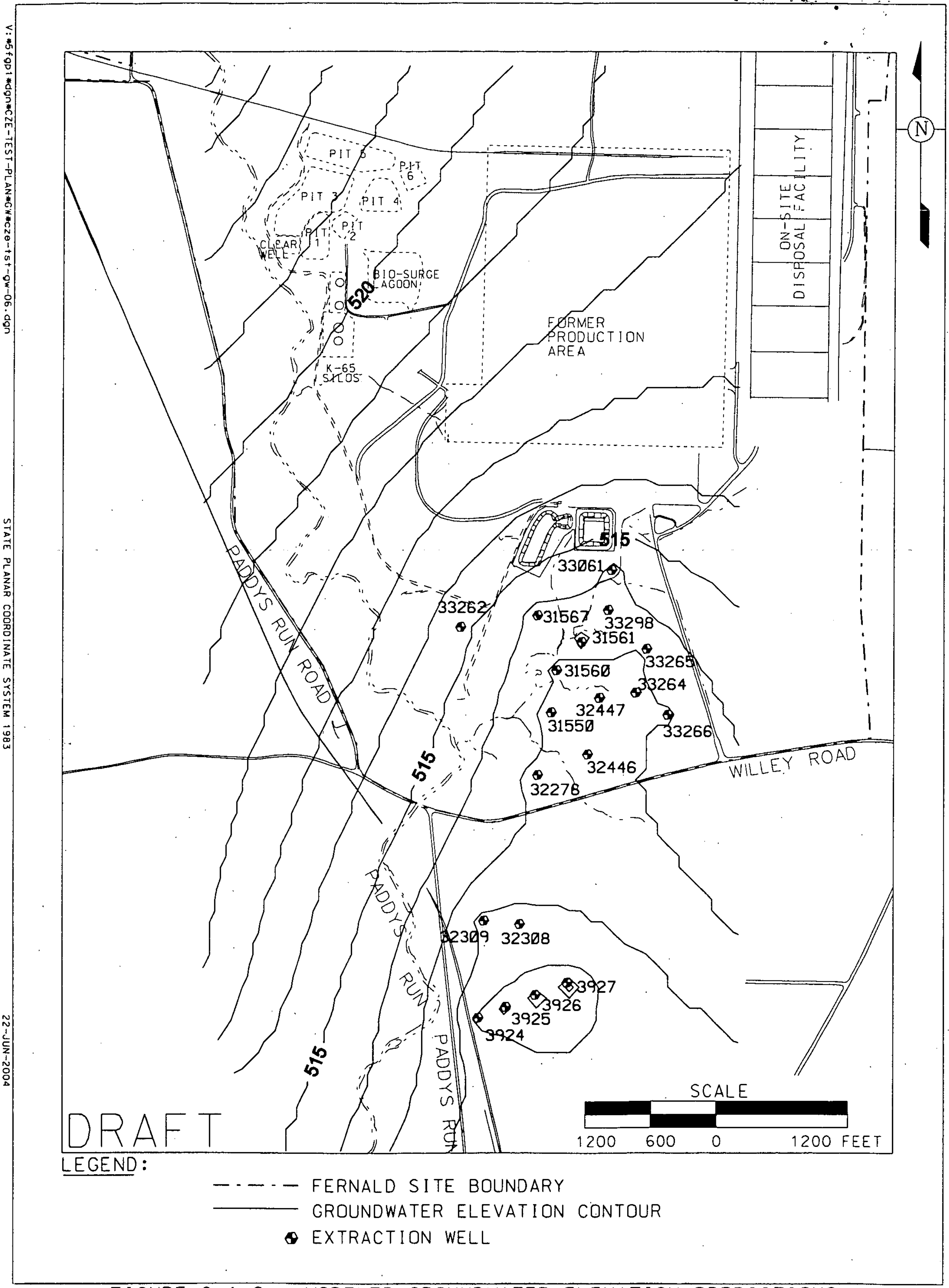

FIGURE 2.1.2. MODELED GROUNDWATER ELEVATION PREDICTIONS, CAWWT CONSTRUCTION PERIOD, 10-1-2004 TO 4-1-2005

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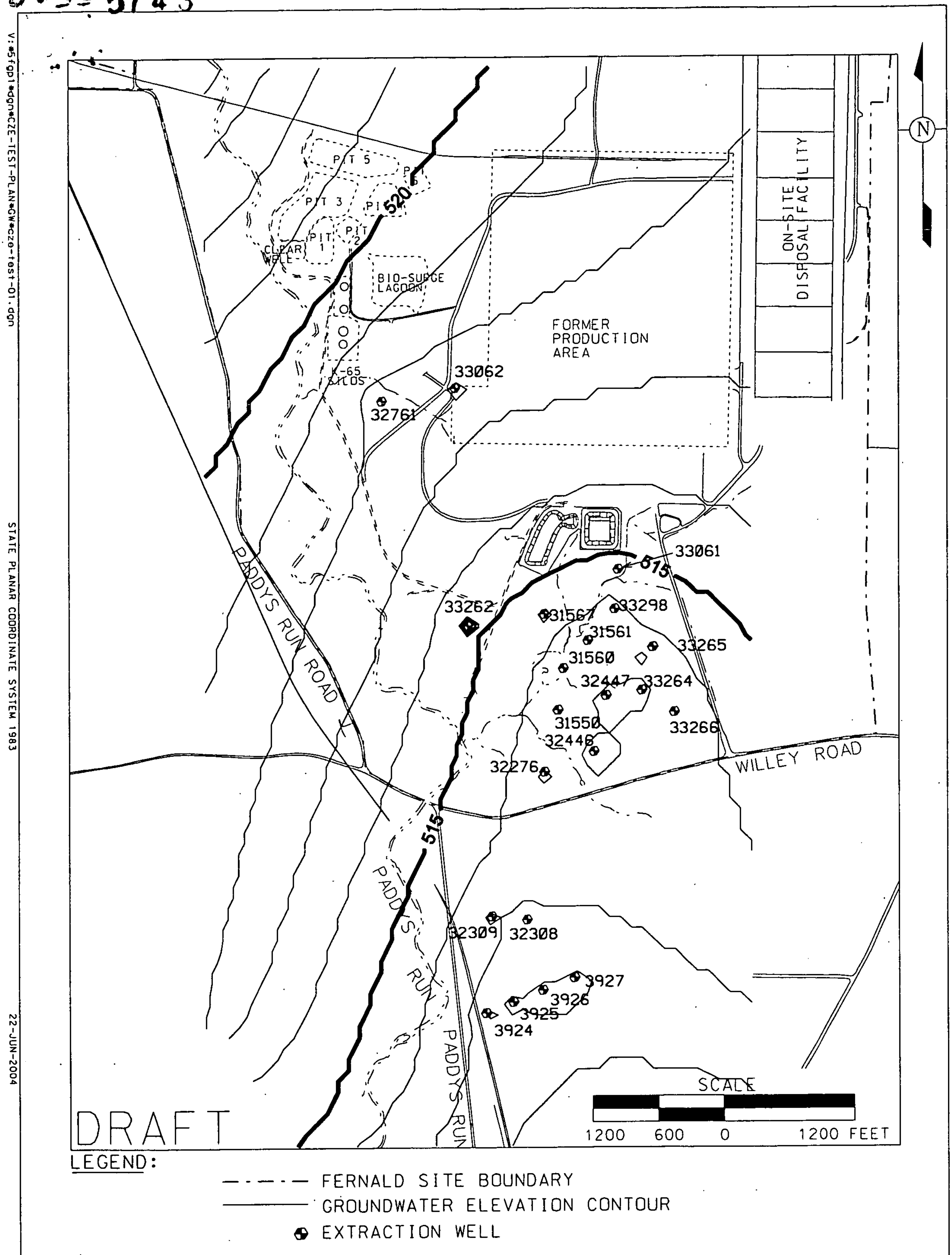

FIGURE 2.1.3. MODELED GROUNDWATER ELEVATION PREDICTIONS, 4-1-2005 TO 4-1-2006, APPROACH C

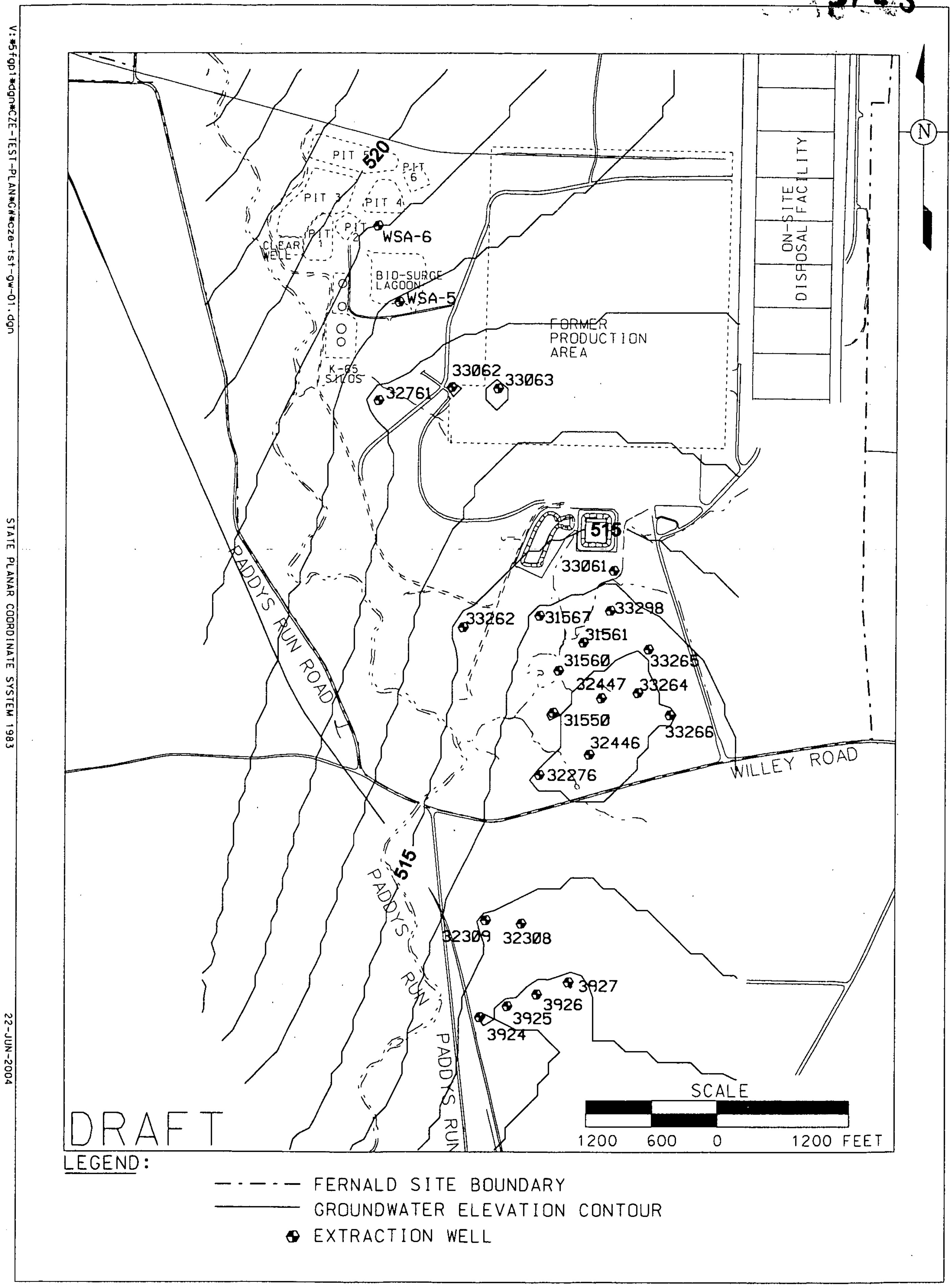

FIGURE 2.1.4. MODELED GROUNDWATER ELEVATION PREDICTIONS, 4-1-2006 TO 4-1-2012, APPROACH C

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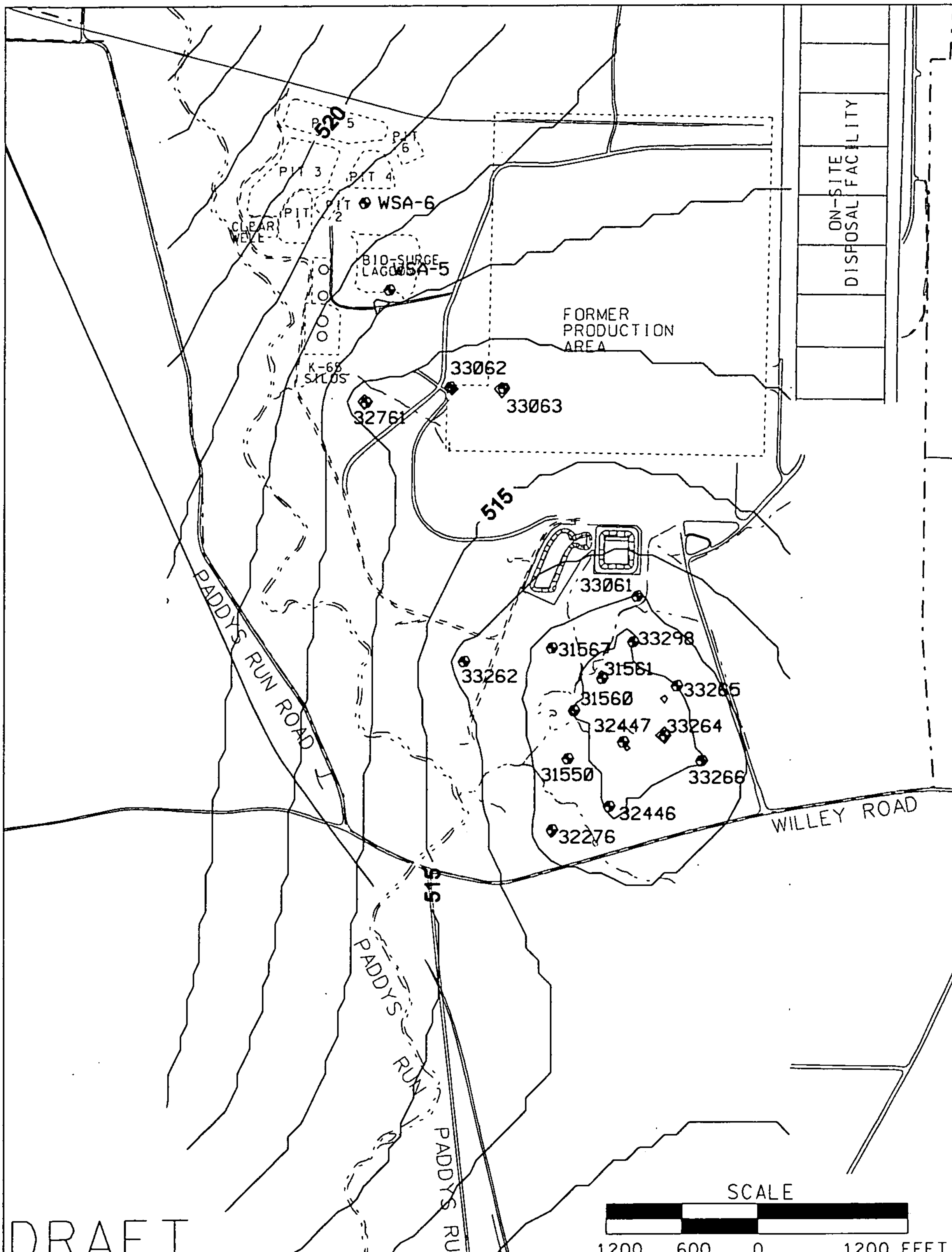
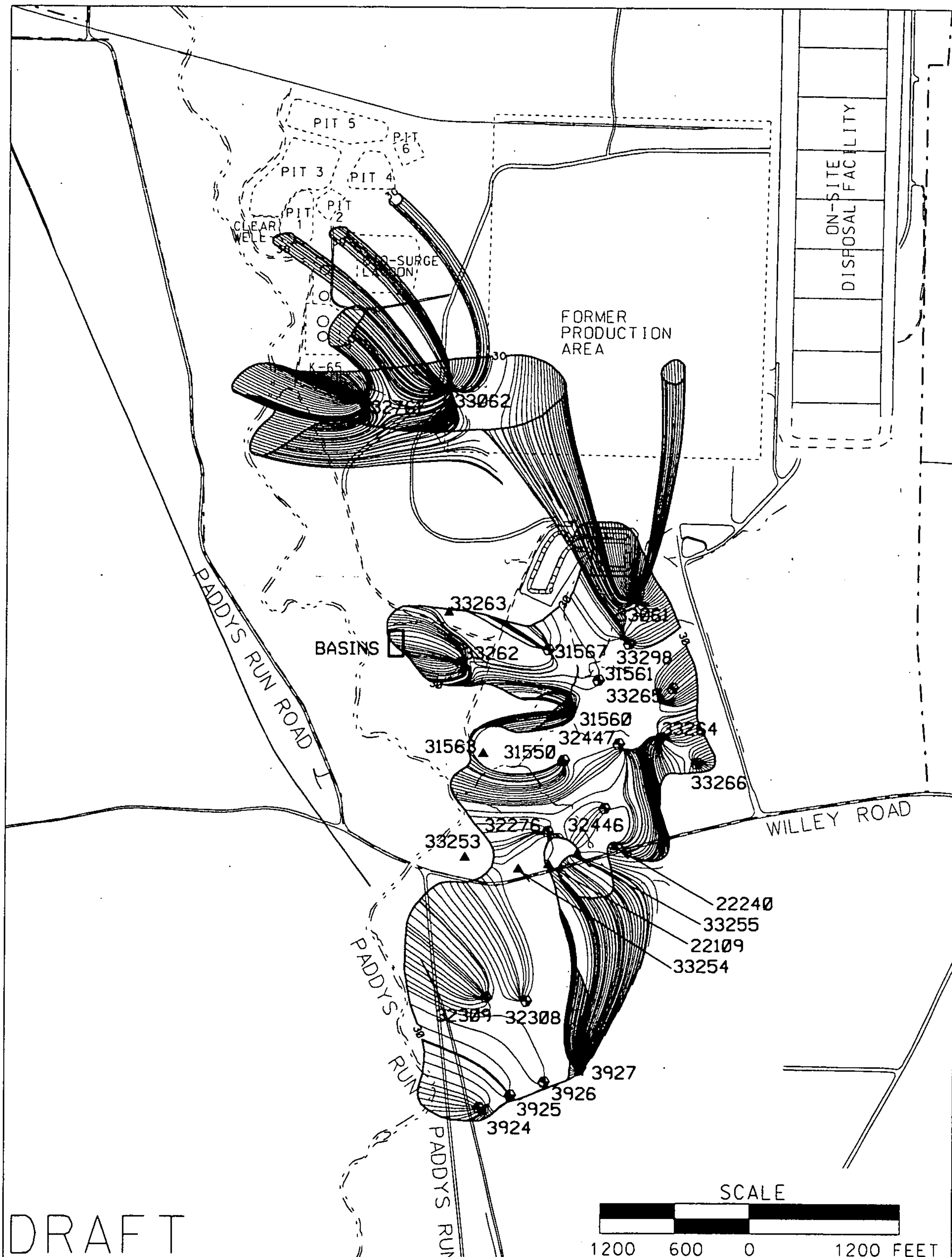


LEGEND:

- — · — · — FERNALD SITE BOUNDARY
- ———— GROUNDWATER ELEVATION CONTOUR
- EXTRACTION WELL

FIGURE 2.1.5. MODELED GROUNDWATER ELEVATION PREDICTIONS, 4-1-2012 TO END, APPROACH C



LEGEND:

- — · — · — FERNALD SITE BOUNDARY
- ———— PARTICLE TRACK
- EXTRACTION WELL
- ▲ RE-INJECTION WELL
- —— 30 —— TOTAL URANIUM CONTOUR (30 µg/L) THROUGH SECOND HALF OF 2003

FIGURE 2.1.6. 10-YEAR, NON-RETARDED PARTICLE TRACKS FROM PLUME BOUNDARY, CURRENT TO 10-1-2004

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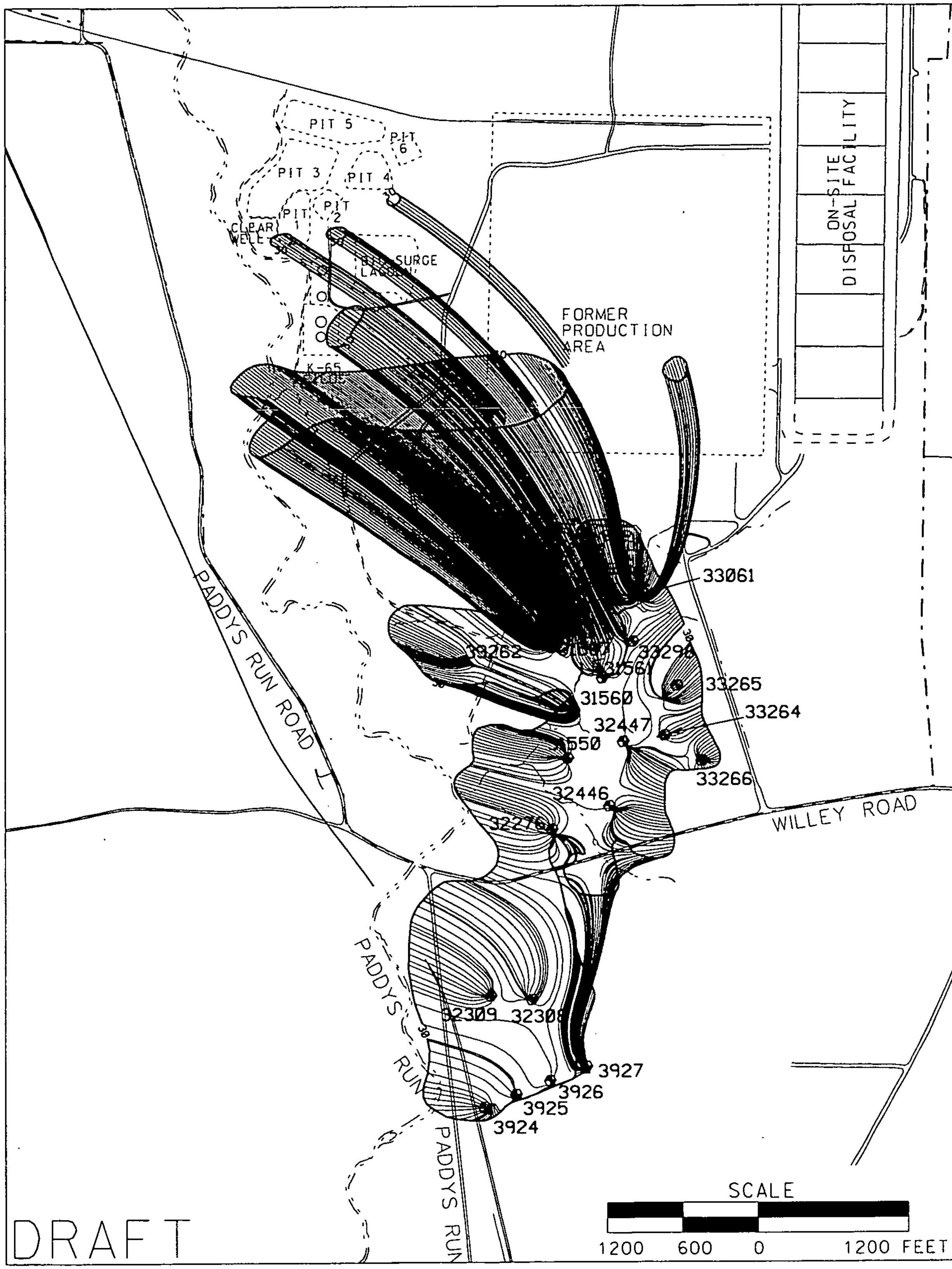

LEGEND:

- FERNALD SITE BOUNDARY
- PARTICLE TRACK
- EXTRACTION WELL
- RE-INJECTION WELL
- 30 TOTAL URANIUM CONTOUR (30 μg/L) THROUGH SECOND HALF OF 2003

STATE PLANAR COORDINATE SYSTEM 1983

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FIGURE 2.1.7. 10-YEAR, NON-RETARDED PARTICLE TRACKS FROM PLUME BOUNDARY, CAWWT CONSTRUCTION PERIOD, 10-1-2004 TO 4-1-2005

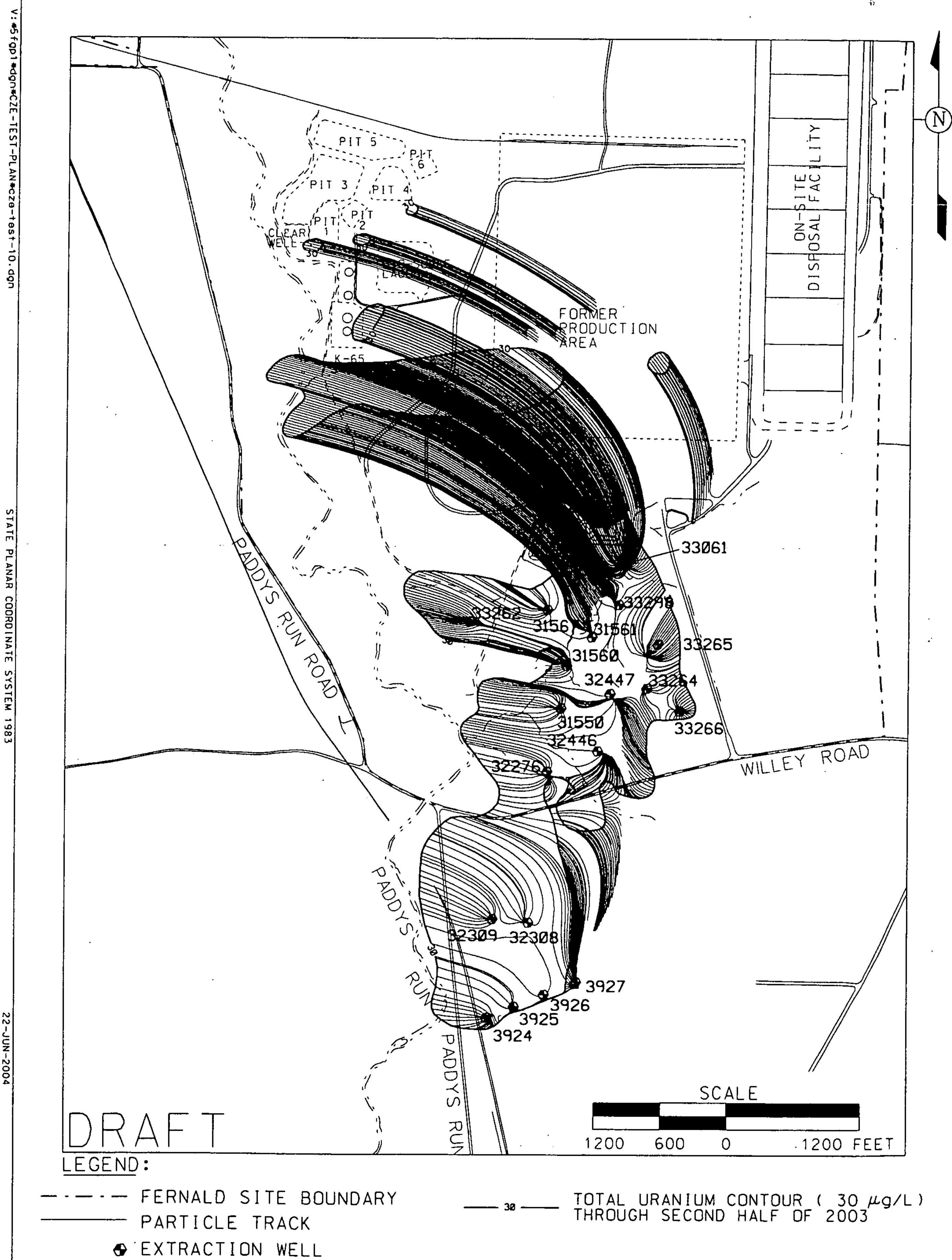

FIGURE 2.1.8. 10-YEAR, NON-RETARDED PARTICLE TRACKS FROM PLUME BOUNDARY, DRY BOUNDARY CONDITIONS, CAWWT CONSTRUCTION PERIOD, 10-1-2004 TO 4-1-2005

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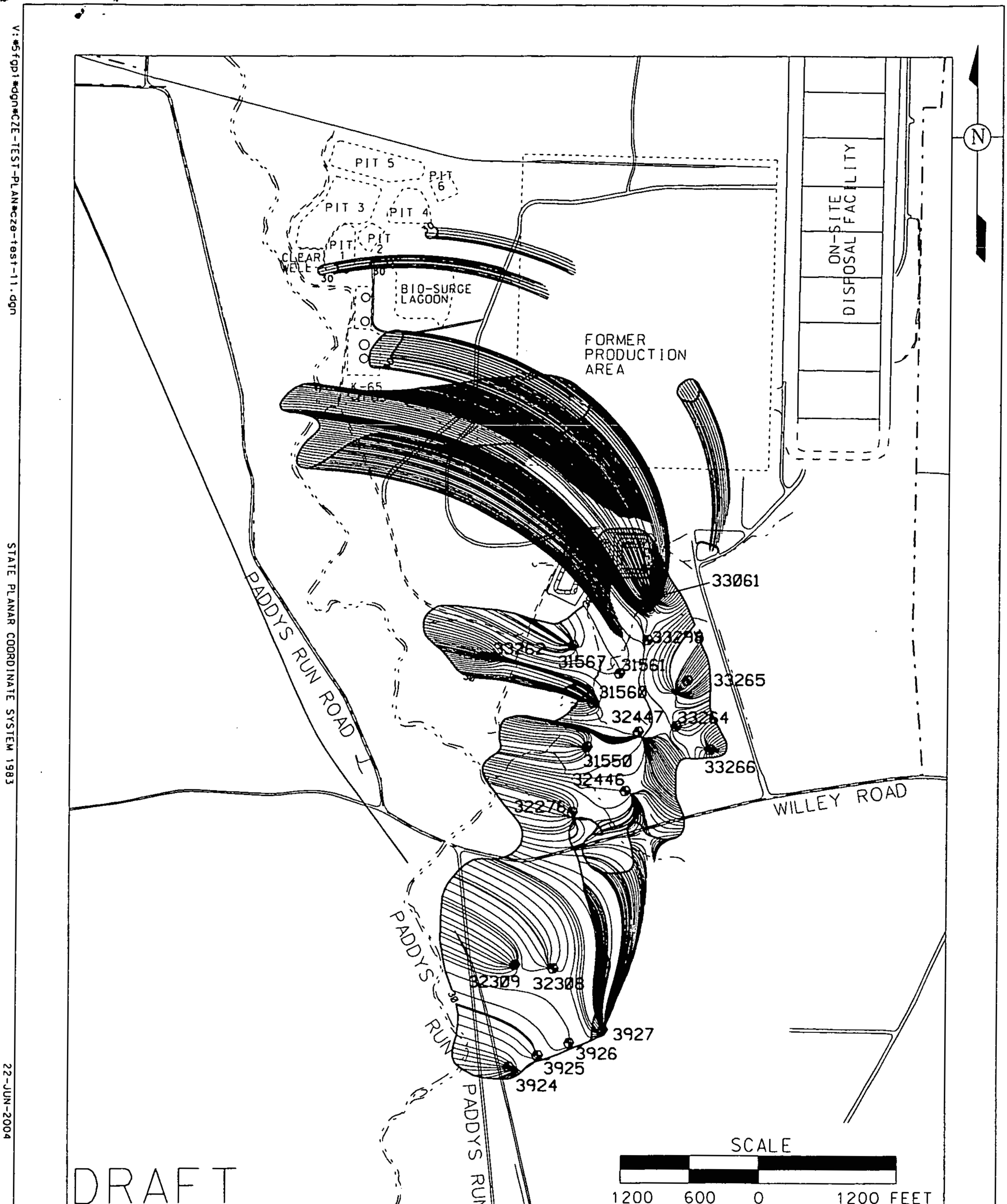

LEGEND:

- FERNALD SITE BOUNDARY
- PARTICLE TRACK
- EXTRACTION WELL
- TOTAL URANIUM CONTOUR (30 µg/L) THROUGH SECOND HALF OF 2003

FIGURE 2.1.9. 10-YEAR, NON-RETARDED PARTICLE TRACKS FROM PLUME BOUNDARY, WET BOUNDARY CONDITIONS, CAWWT CONSTRUCTION PERIOD, 10-1-2004 TO 4-1-2005

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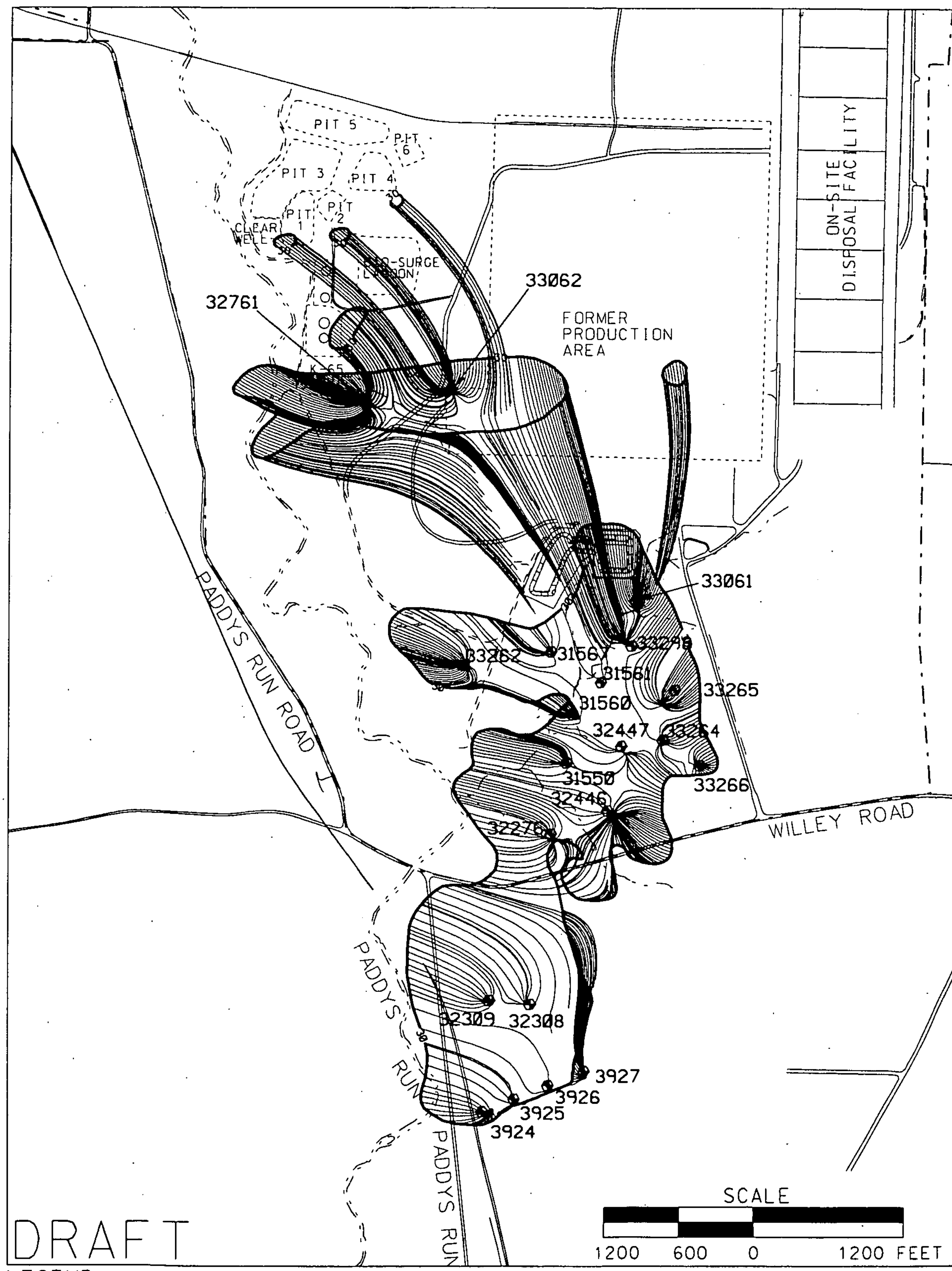

LEGEND:

- · - · - FERNALD SITE BOUNDARY
- ——— PARTICLE TRACK
- EXTRACTION WELL
- —30— TOTAL URANIUM CONTOUR (30 μg/L) THROUGH SECOND HALF OF 2003

FIGURE 2.1.10. 10-YEAR, NON-RETARDED PARTICLE TRACKS FROM PLUME BOUNDARY, APPROACH C, 4-1-2005 TO 4-1-2006

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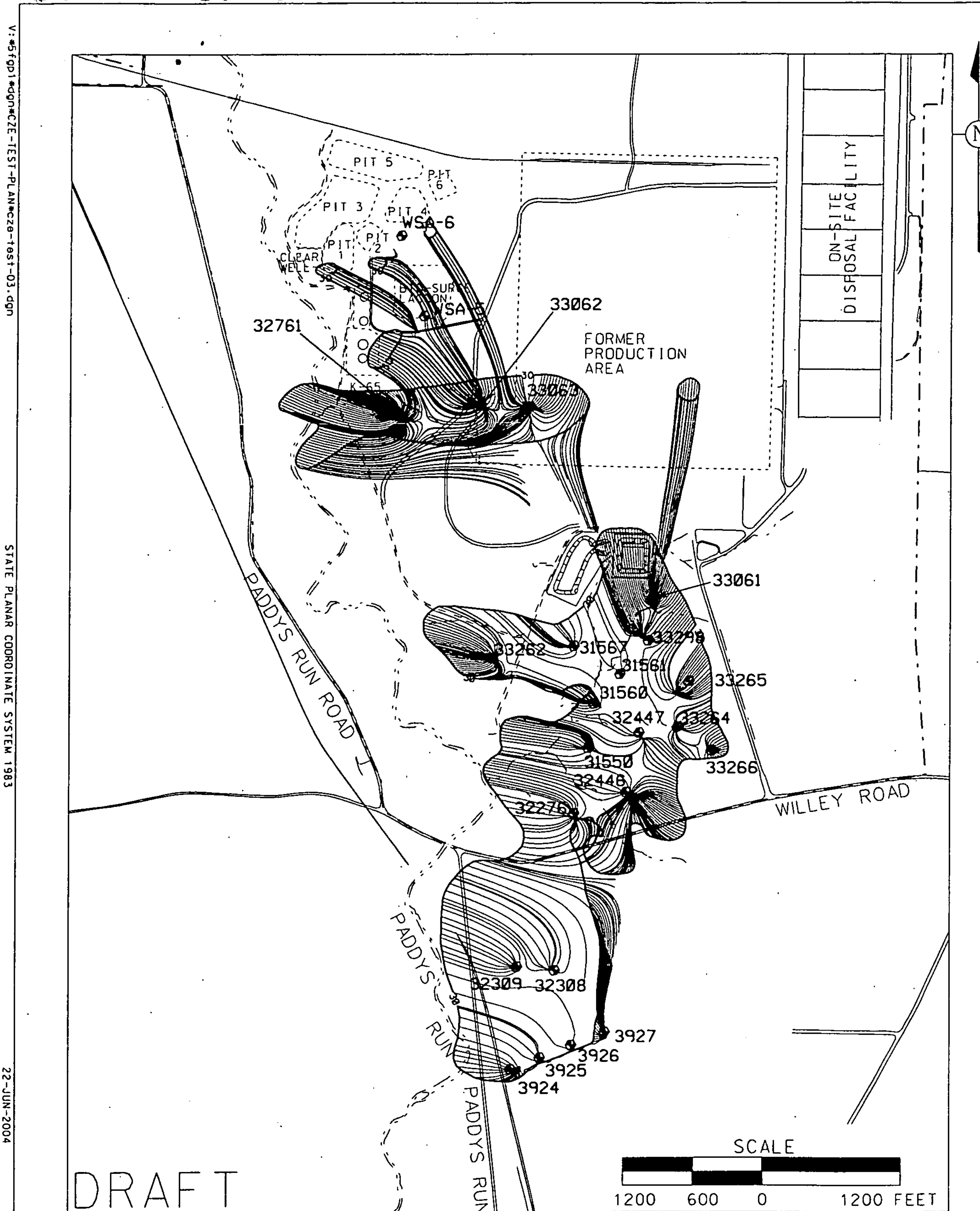

LEGEND:

- — · — · — FERNALD SITE BOUNDARY
- ———— PARTICLE TRACK
- EXTRACTION WELL
- —— 30 —— TOTAL URANIUM CONTOUR (30 μg/L) THROUGH SECOND HALF OF 2003

FIGURE 2.1.11. 10-YEAR, NON-RETARDED PARTICLE TRACKS FROM PLUME BOUNDARY, APPROACH C, 4-1-2006 TO 4-1-2012

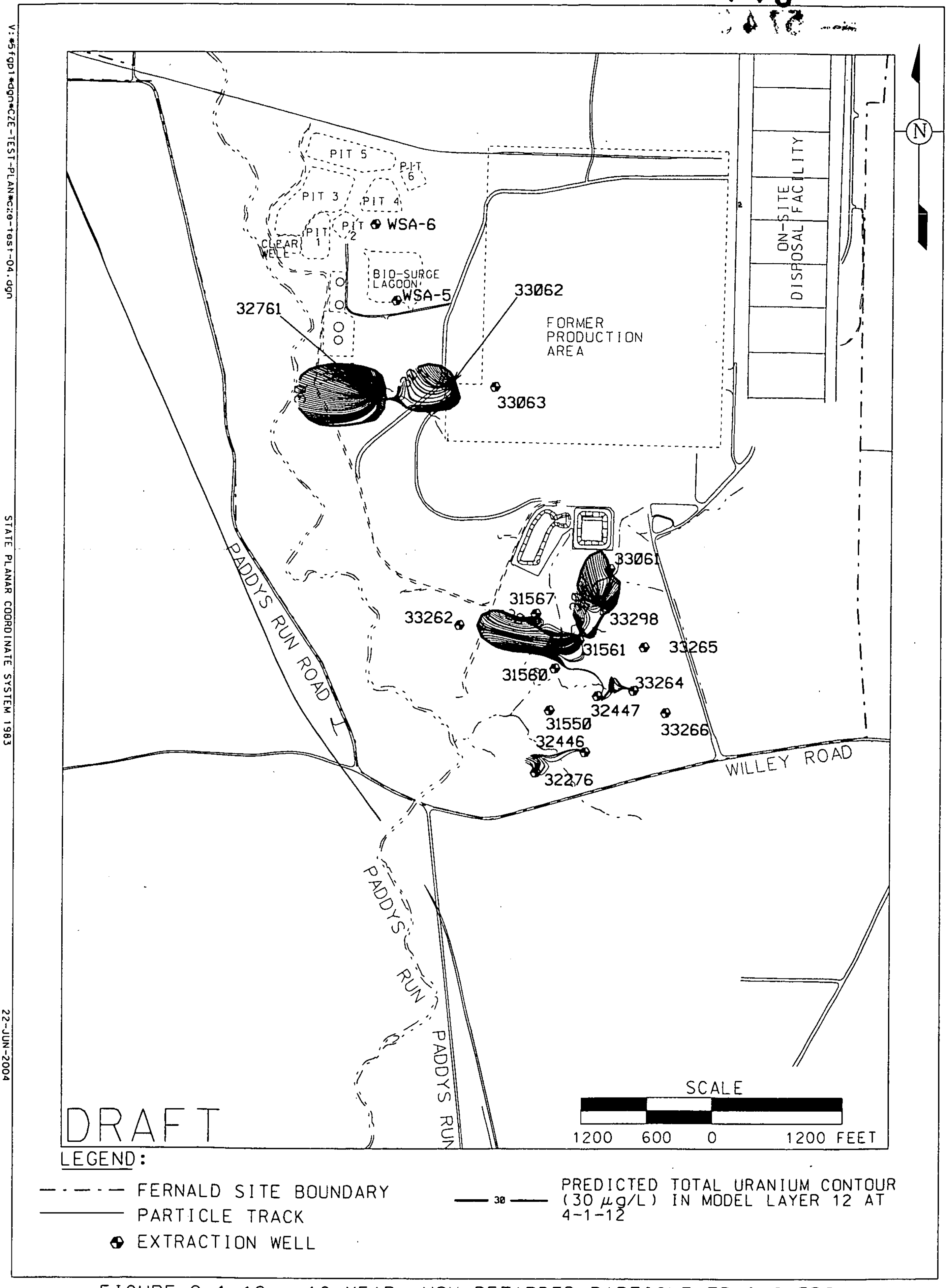

FIGURE 2.1.12. 10-YEAR, NON-RETARDED PARTICLE TRACKS FROM PLUME BOUNDARY, APPROACH C, 4-1-2012 TO END

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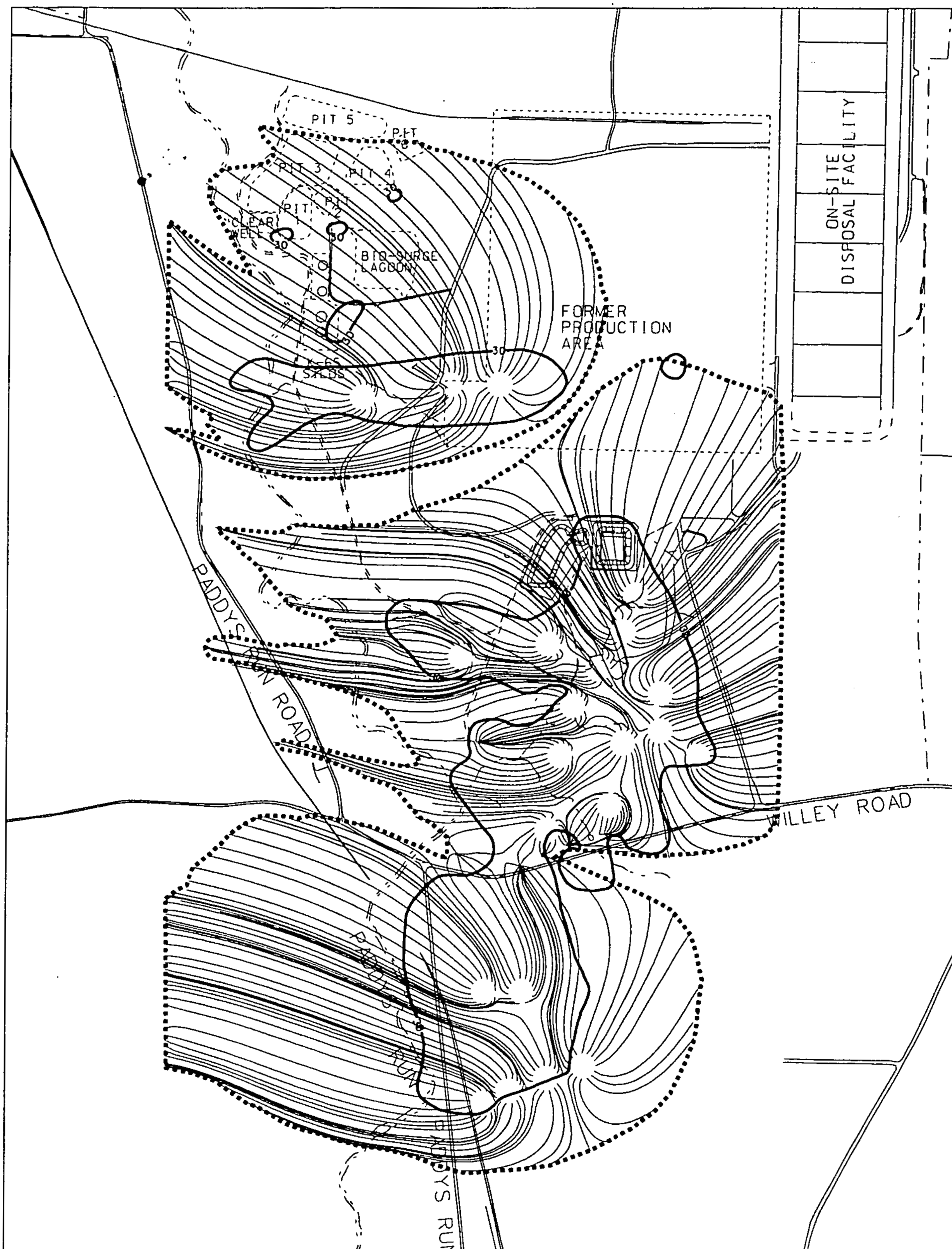


V:\5fop1\dgn\CZE-TEST-PLAN\cze-test-16.dgn

STATE PLANAR COORDINATE SYSTEM 1983

22-JUN-2004

LEGEND:

- ‒ · ‒ · ‒ FERNALD SITE BOUNDARY
- ············ 10 YEAR, TIME-OF-TRAVEL REMEDIATION FOOTPRINT
- ——— MODELED PARTICLE TRACKS
- —30— 30 $\mu g/L$ TOTAL URANIUM PLUME FROM SECOND HALF OF 2003

SCALE

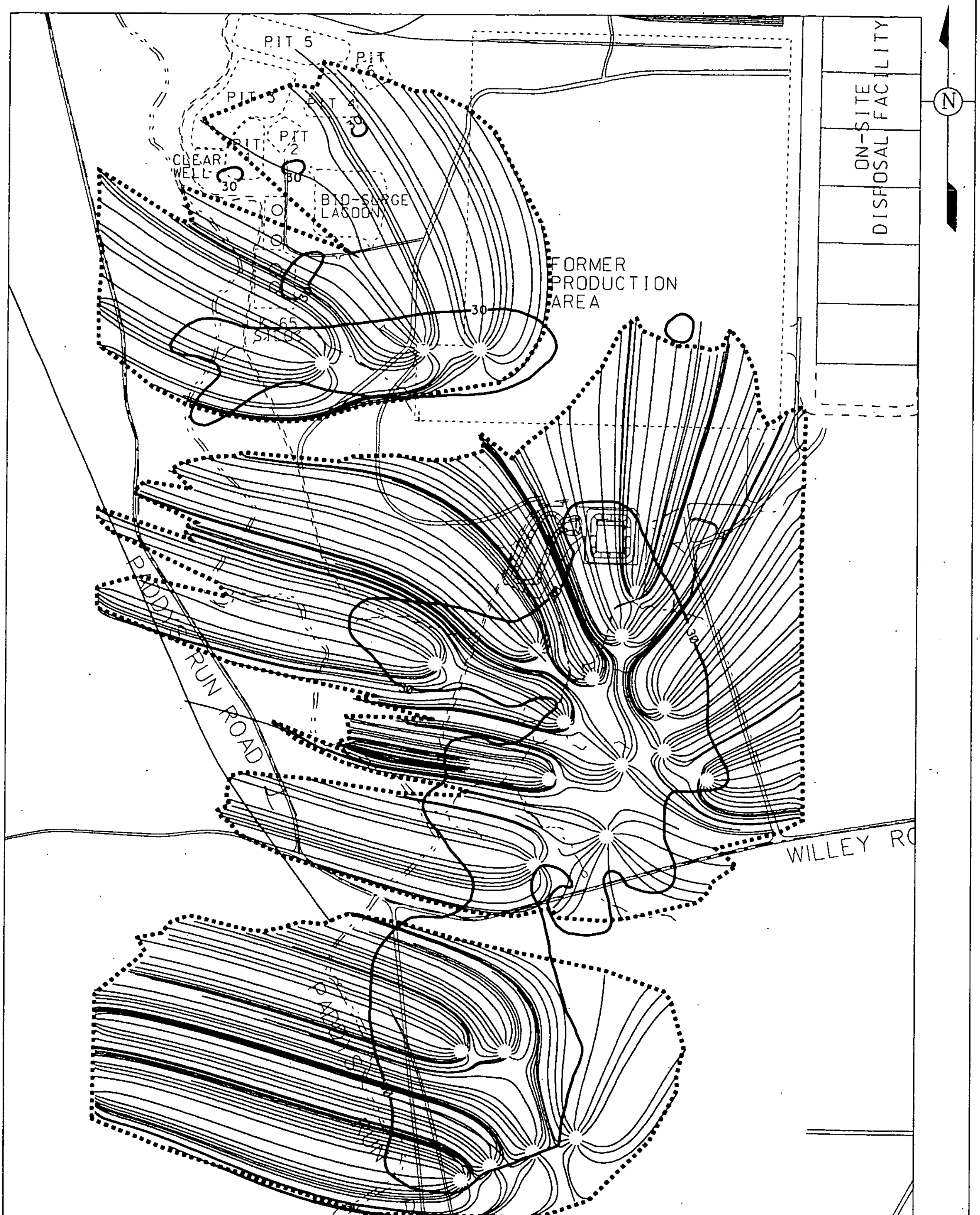
1200 600 0 1200 FEET

DRAFT

FIGURE 2.1.13. 10 YEAR, TIME-OF-TRAVEL REMEDIATION FOOTPRINT, WITH RE-INJECTION

5743

V:*5fgp1*dgn*CZE-TEST-PLAN*cze-test-17.dgn



STATE PLANAR COORDINATE SYSTEM 1983

22-JUN-2004

LEGEND:

FERNALD SITE BOUNDARY

10-YEAR, TIME-OF-TRAVEL REMEDIATION FOOTPRINT

PARTICALE TRACK

TOTAL URANIUM FOOTPRINT SECOND HALF 2003

SCALE

1000 500 0 1000 FEET

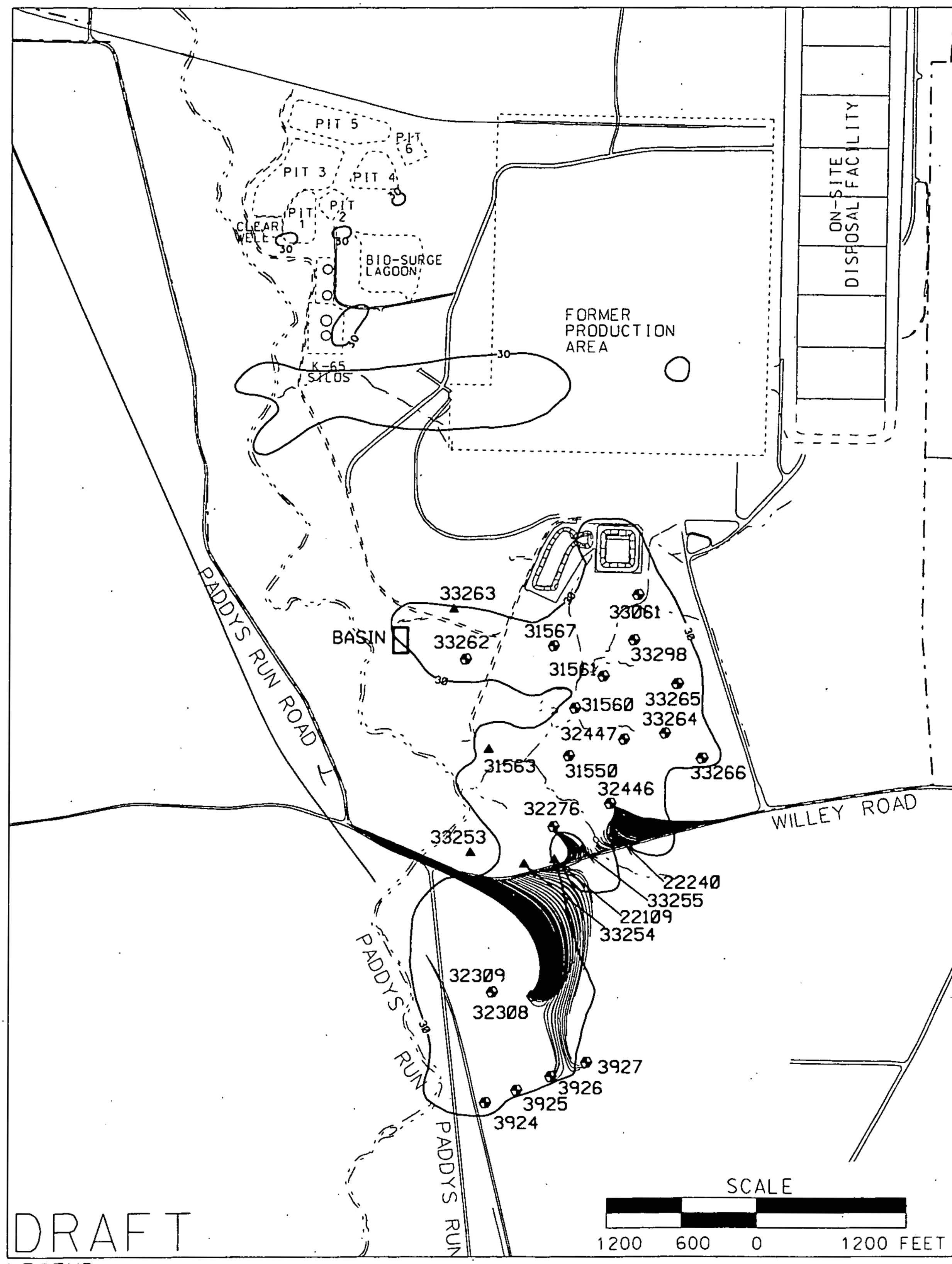
DRAFT

FIGURE 2.1.14. 10-YEAR TIME-OF-TRAVEL REMEDIATION FOOTPRINT, WITHOUT RE-INJECTION

V:*5fop1*dgn*CZE-TEST-PLAN*cze-test-24.dgn

STATE PLANAR COORDINATE SYSTEM 1983

24-JUN-2004



LEGEND:

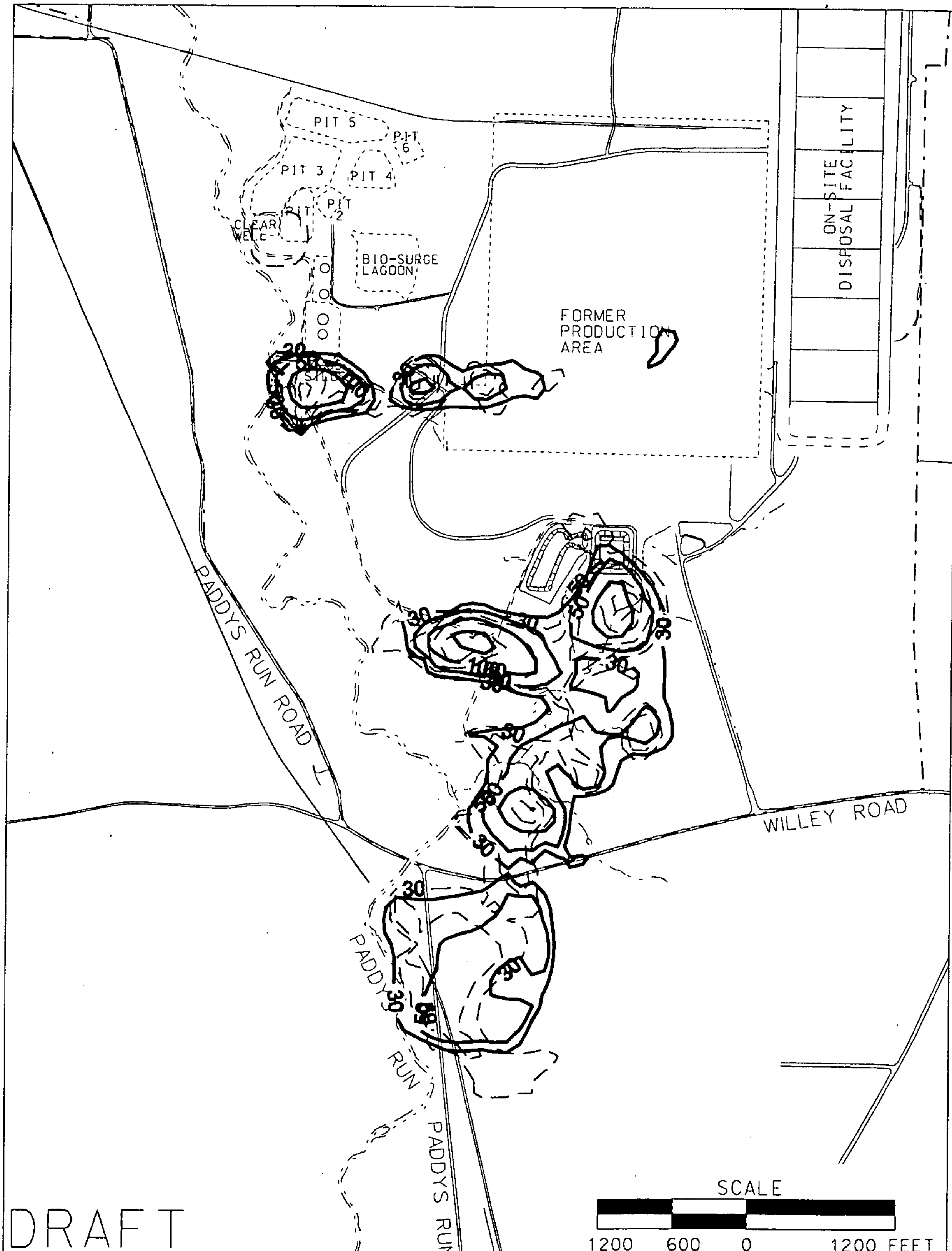
- — - — - — FERNALD SITE BOUNDARY
- — - — - — PARTICLE TRACK
- ▲ RE-INJECTION WELL
- EXTRACTION WELL
- —— 30 —— 30 $\mu g/L$ TOTAL URANIUM PLUME FROM SECOND HALF OF 2003

FIGURE 2.1.15. 10-YEAR, TIME OF TRAVEL PARTICLE PATHS. NO RE-INJECTION. PARTICLES SEEDED ALONG WILLEY ROAD.

V:\5fgp1\dgn\CZE-TEST-PLAN\cze-test-22.dgn

STATE PLANAR COORDINATE SYSTEM 1983

24-JUN-2004



LEGEND:

- · — · — FERNALD SITE BOUNDARY
- ——— 12-31-2002 INITIAL CONDITIONS PLUS 1 YEAR, PUMPING MODEL LAYER 12
- – – – – 12-31-2003 INITIAL CONDITIONS MODEL LAYER 12

FIGURE 2.2.1. COMPARISON OF INITIAL CONDITIONS

Figure 2.2.2 Horizontal Variograms

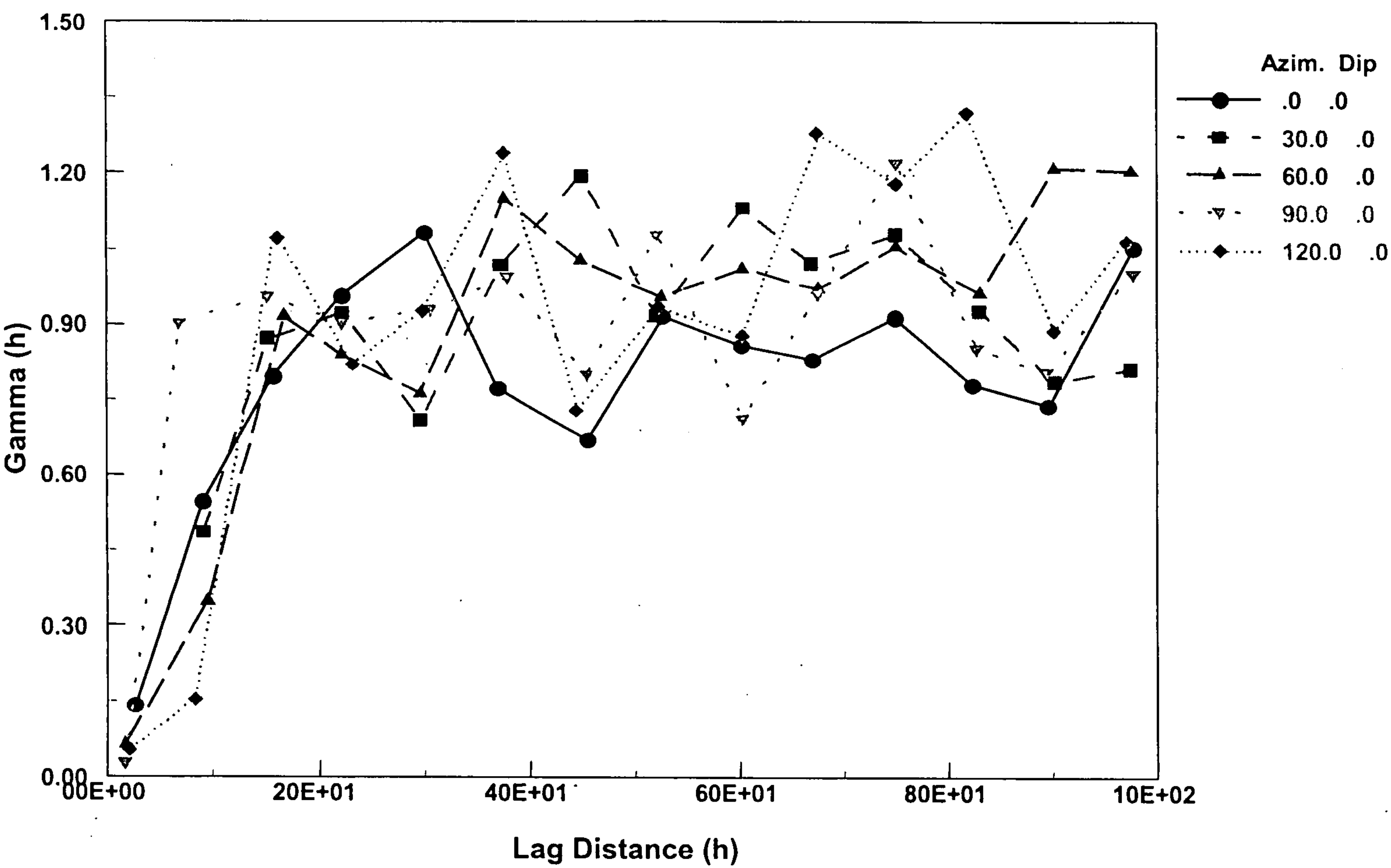
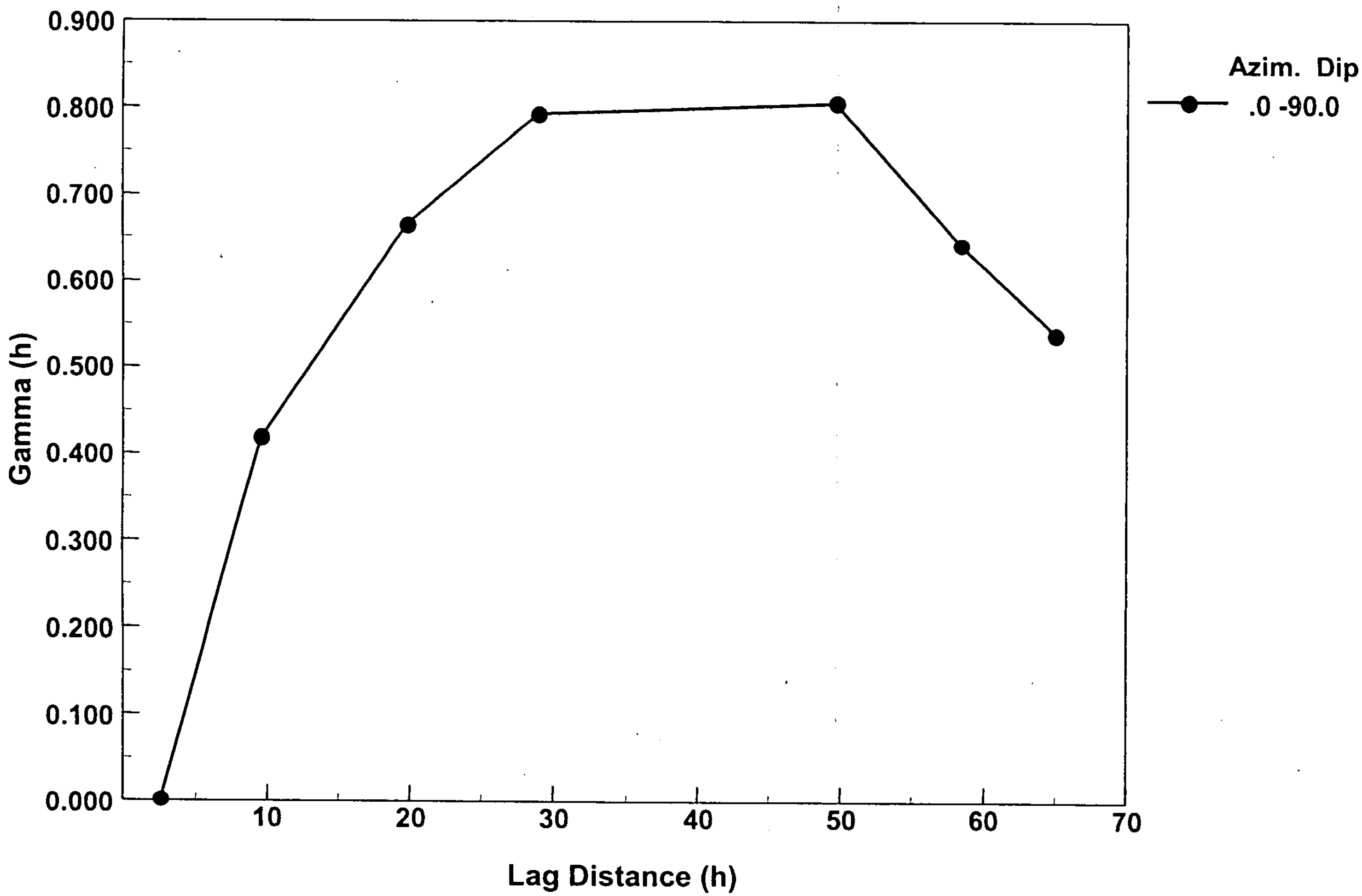


Figure 2.2.3 Vertical Variogram



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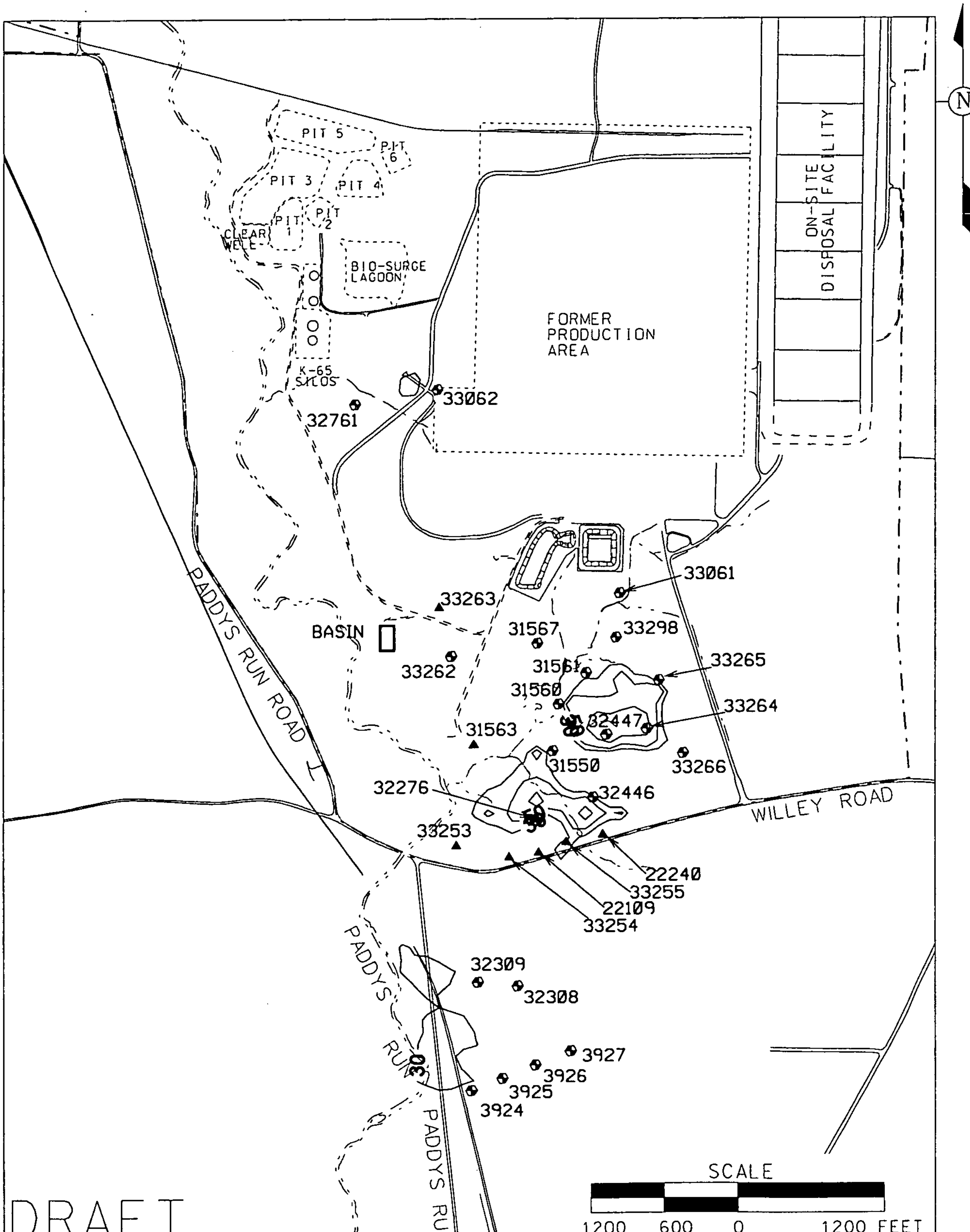


LEGEND:

- — · — · — FERNALD SITE BOUNDARY
- ———— TOTAL URANIUM CONTOUR
- EXTRACTION WELL
- ▲ INJECTION WELL

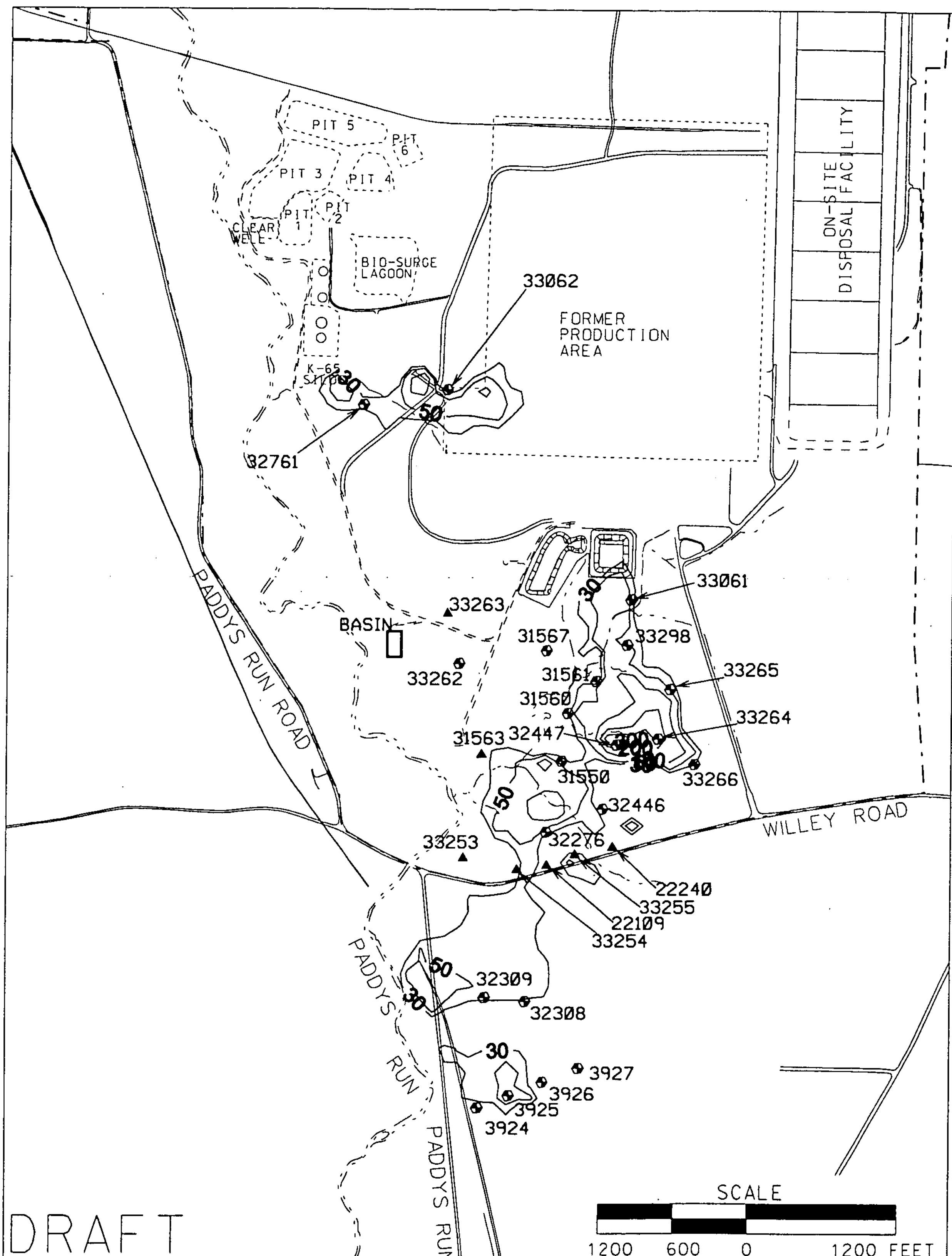
V:\5fpd\dgn\CZE-TEST-PLAN\INT-COND\cze-tst-int-cnd-04.dgn STATE PLANAR COORDINATE SYSTEM 1983 24-JUN-2004

FIGURE 2.2.4. MODEL LAYER 9, INITIAL CONDITIONS

V:*5fgp1*dgn*CZE-TEST-PLAN*INT-COND*cze-tst-int-cnd-01.dgn

STATE PLANAR COORDINATE SYSTEM 1983

24-JUN-2004



LEGEND:

- FERNALD SITE BOUNDARY
- TOTAL URANIUM CONTOUR
- EXTRACTION WELL
- INJECTION WELL

FIGURE 2.2.5. MODEL LAYER 10, INITIAL CONDITIONS

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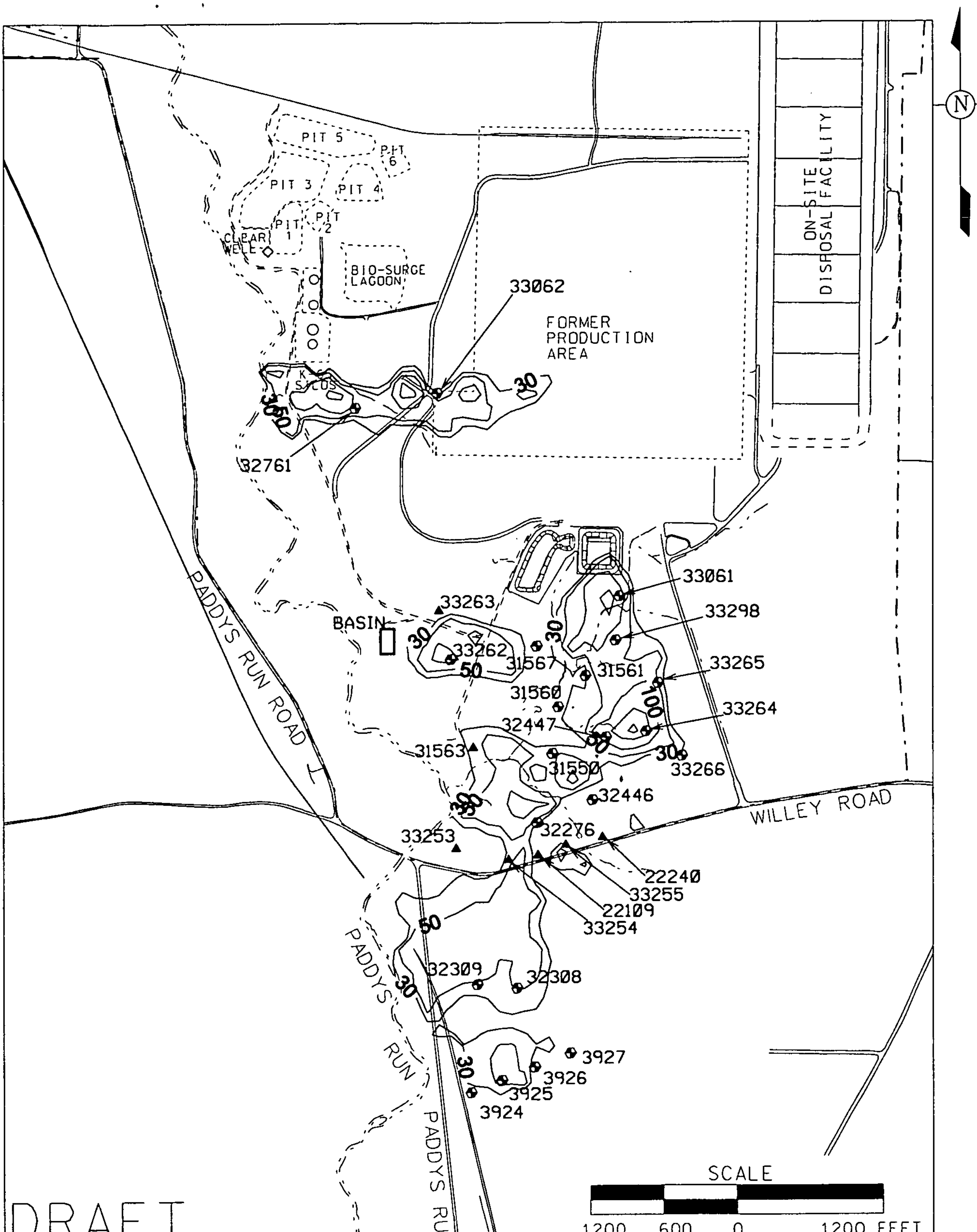
V:*5fgp1*dgn*CZE-TEST-PLAN*INT-COND*cze-tst-int-cnd-02.dgn

STATE PLANAR COORDINATE SYSTEM 1983

24-JUN-2004

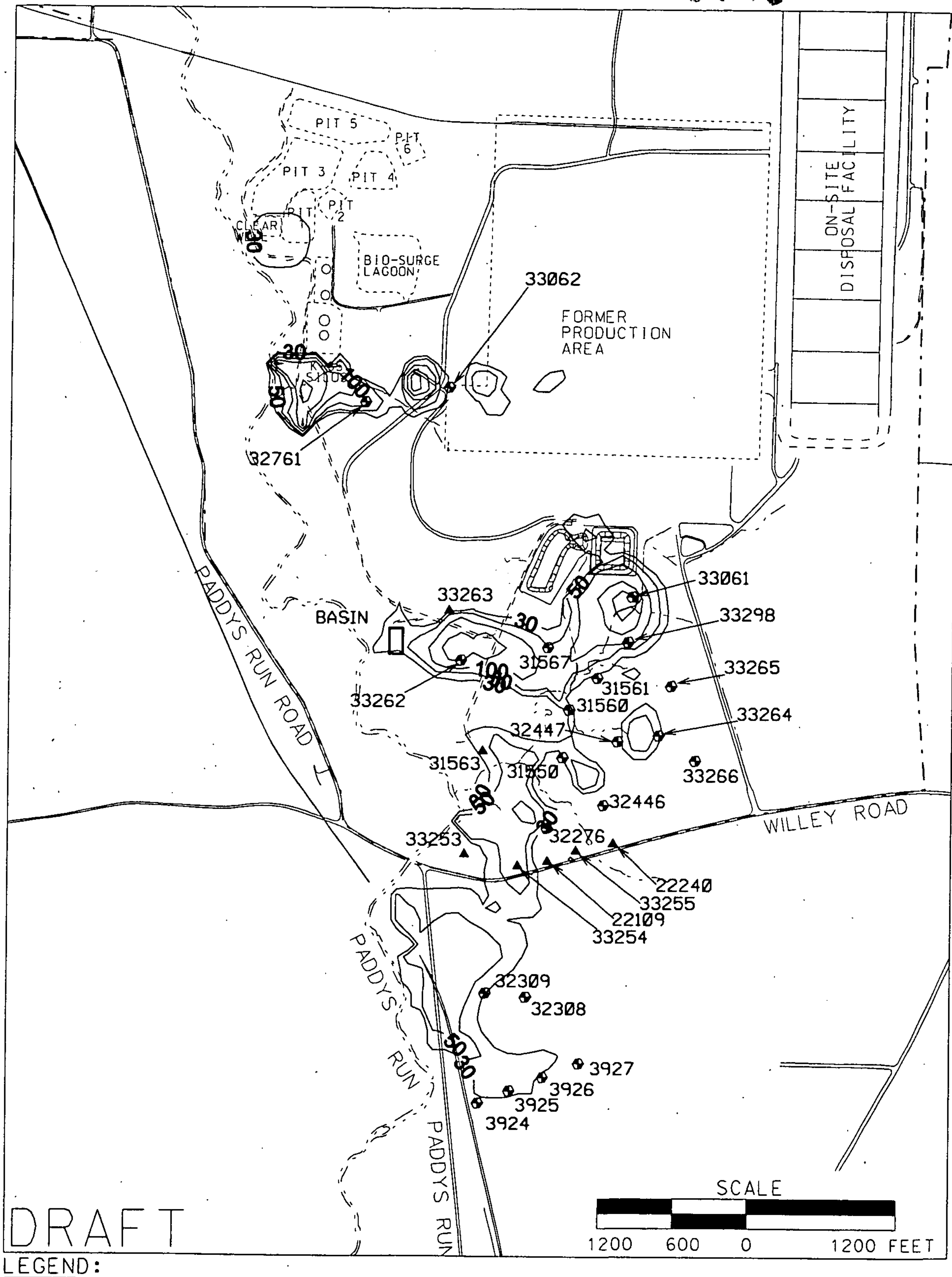


LEGEND:

- FERNALD SITE BOUNDARY
- TOTAL URANIUM CONTOUR
- EXTRACTION WELL
- INJECTION WELL

FIGURE 2.2.6. MODEL LAYER 11, INITIAL CONDITIONS

5743



V:*5fgp1*dgn*CZE-TEST-PLAN*INT-COND*cze-tst-int-cnd-03.dgn

STATE PLANAR COORDINATE SYSTEM 1983

24-JUN-2004

LEGEND:

- FERNALD SITE BOUNDARY
- TOTAL URANIUM CONTOUR
- EXTRACTION WELL
- INJECTION WELL

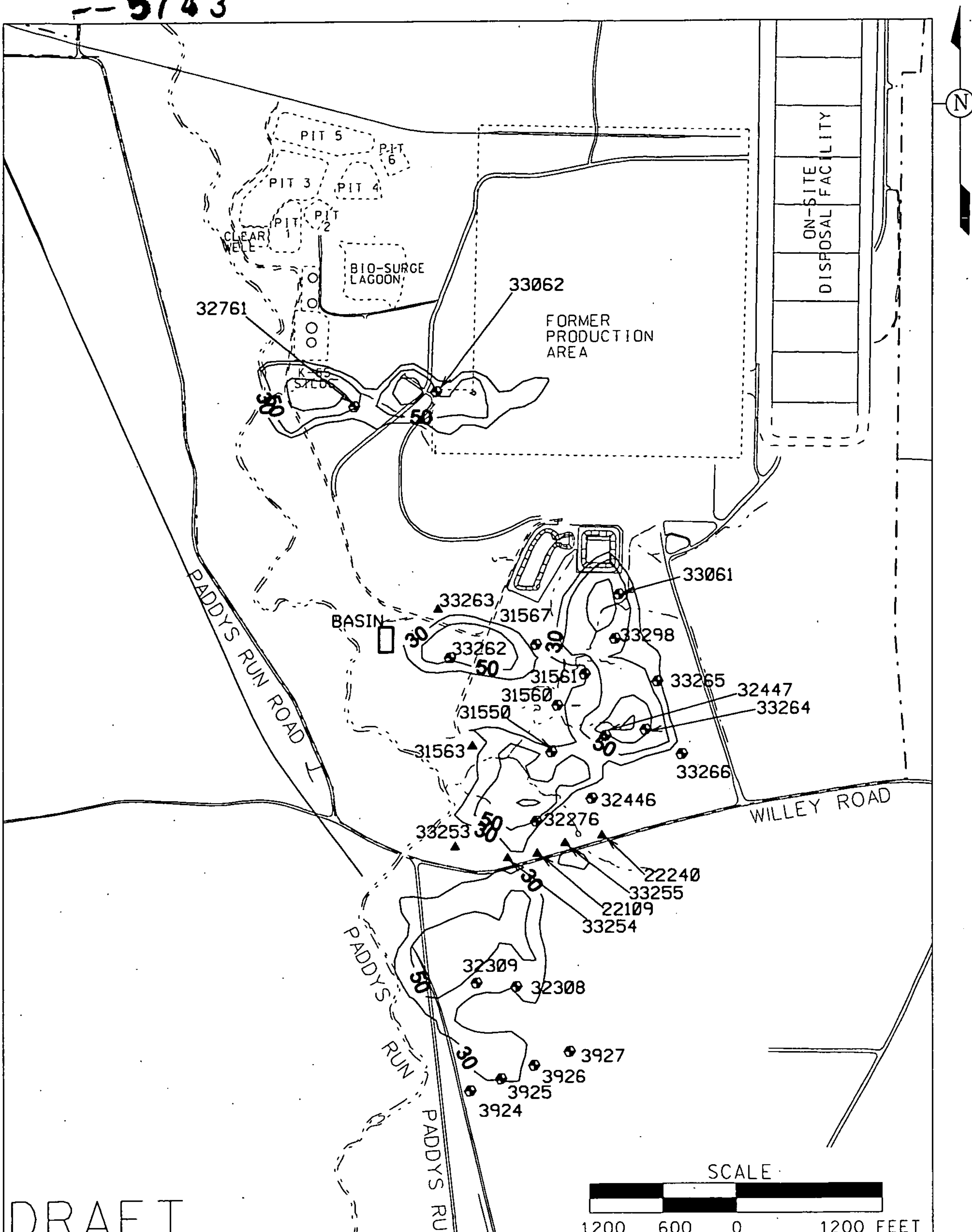
FIGURE 2.2.7. MODEL LAYER 12, INITIAL CONDITIONS

5743

V:*5fop1*dgn*CZE-TEST-PLAN*TRANSPORT*cze-tst-trans-01.dgn

STATE PLANAR COORDINATE SYSTEM 1983

24-JUN-2004

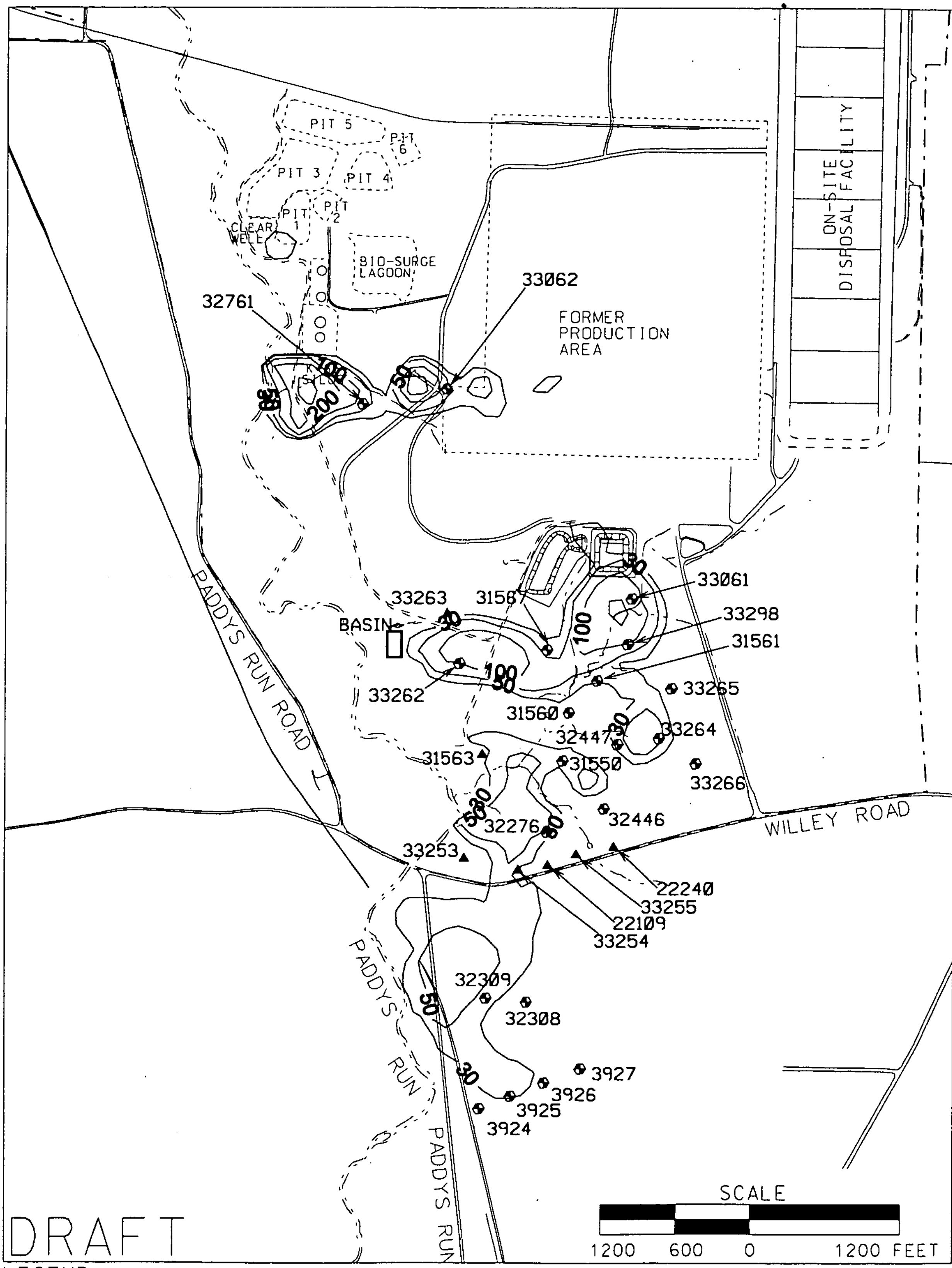


LEGEND:

- — · — · — FERNALD SITE BOUNDARY
- ———— TOTAL URANIUM CONTOUR
- ⊕ EXTRACTION WELL
- ▲ INJECTION WELL

FIGURE 2.2.8. MODEL LAYER 11, PLUME AT 10-1-2004

V:*5fgpl*dgn*CZE-TEST-PLAN*TRANSPORT*cze-tst-trans-07.dgn



LEGEND:

- FERNALD SITE BOUNDARY
- TOTAL URANIUM CONTOUR
- EXTRACTION WELL
- INJECTION WELL

FIGURE 2.2.9. MODEL LAYER 12, PLUME AT 10-1-2004

STATE PLANAR COORDINATE SYSTEM 1983

24-JUN-2004

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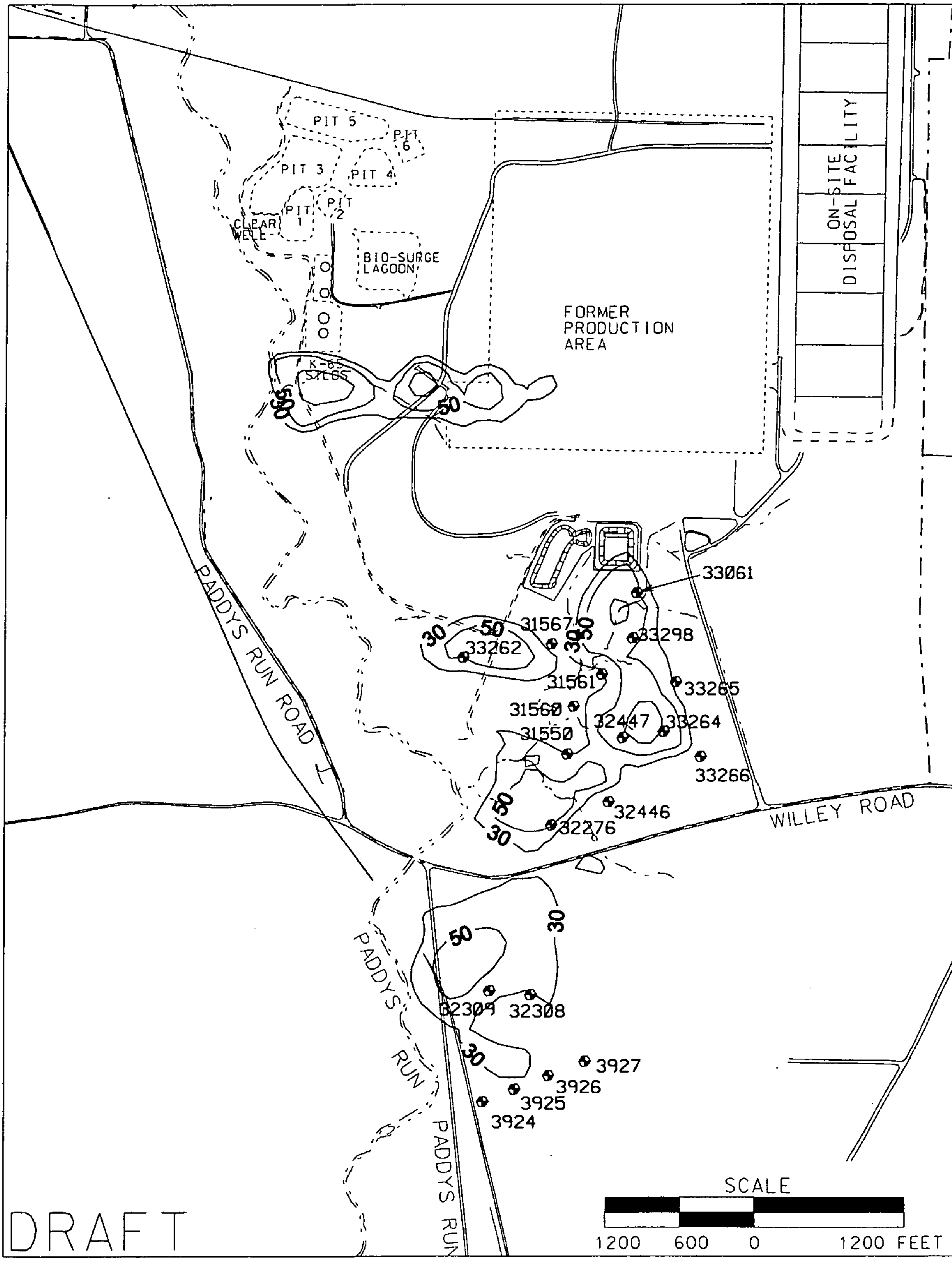

LEGEND:

—·—·— FERNALD SITE BOUNDARY

——— TOTAL URANIUM CONTOUR

⊕ EXTRACTION WELL

FIGURE 2.2.10. MODEL LAYER 11, PLUME AT 4-1-2005

V:*5fgp1*dgn*CZE-TEST-PLAN*TRANSPORT*cze-tst-trans-02.dgn

STATE PLANAR COORDINATE SYSTEM 1983

24-JUN-2004

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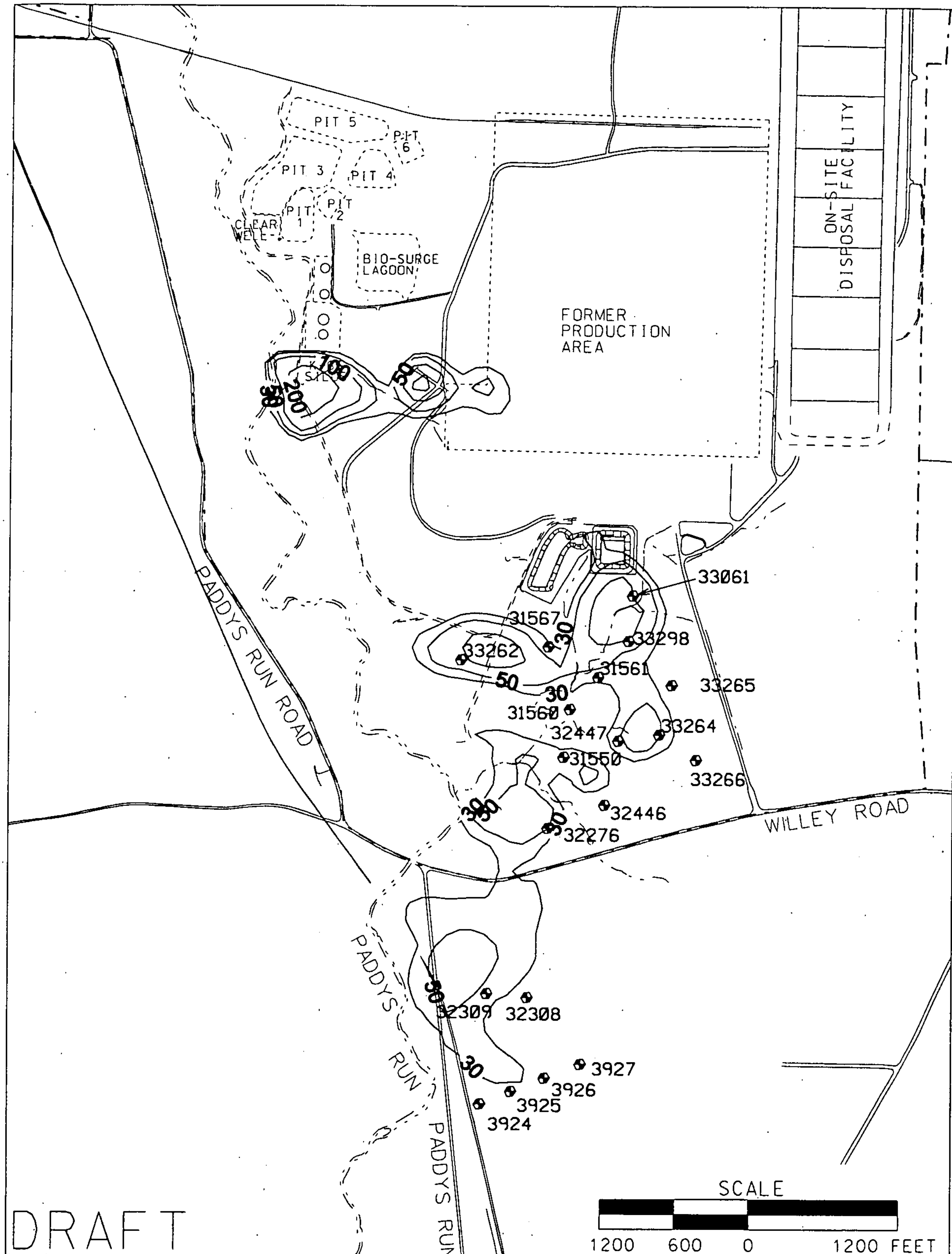
STATE PLANAR COORDINATE SYSTEM 1983

24-JUN-2004



LEGEND:

- FERNALD SITE BOUNDARY
- TOTAL URANIUM CONTOUR
- EXTRACTION WELL

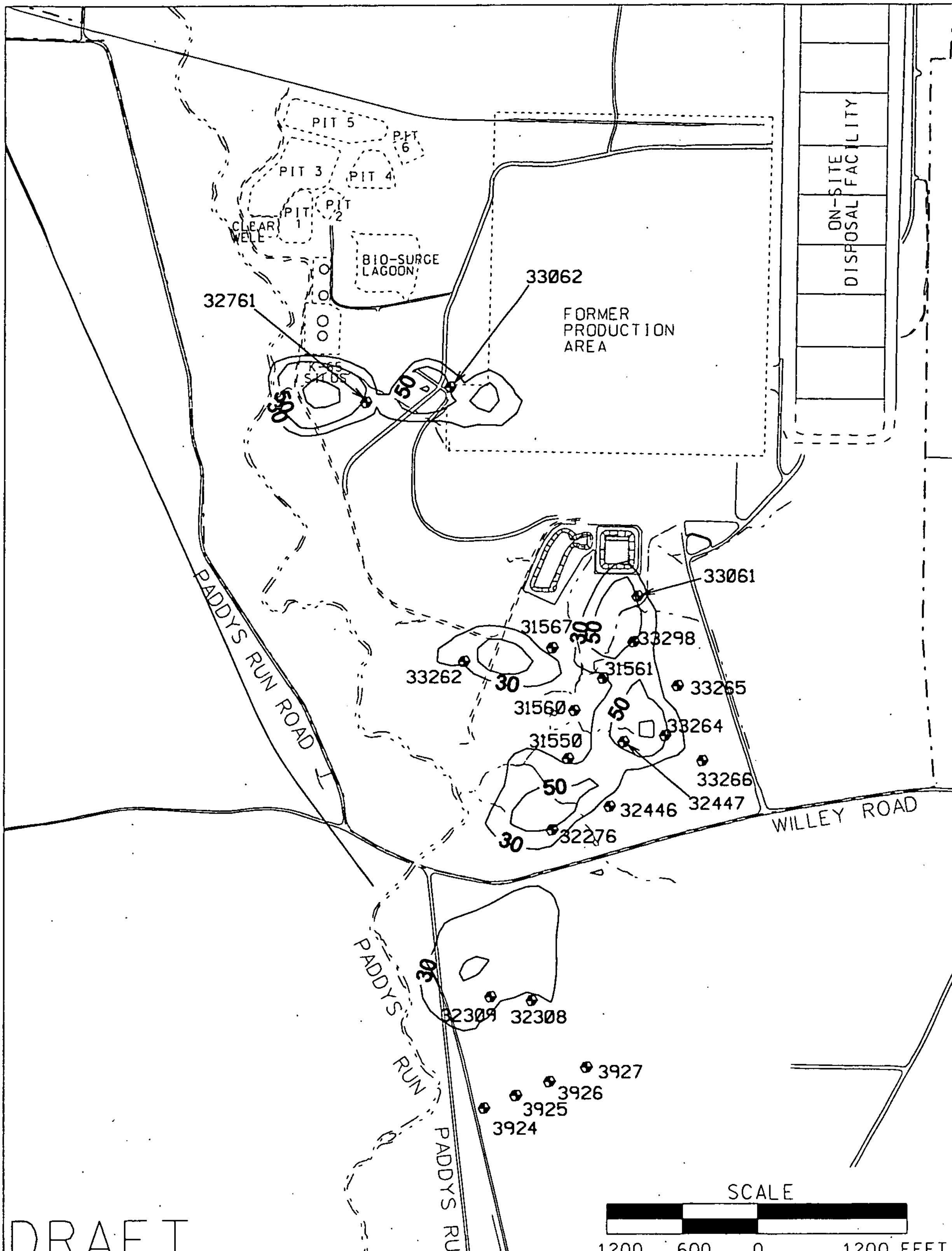
FIGURE 2.2.11. MODEL LAYER 12, PLUME AT 4-1-2005

5743 -- 5743

V:*5fgp1*dgn*CZE-TEST-PLAN*TRANSPORT*cze-tst-trans-03.dgn

STATE PLANAR COORDINATE SYSTEM 1983

24-JUN-2004



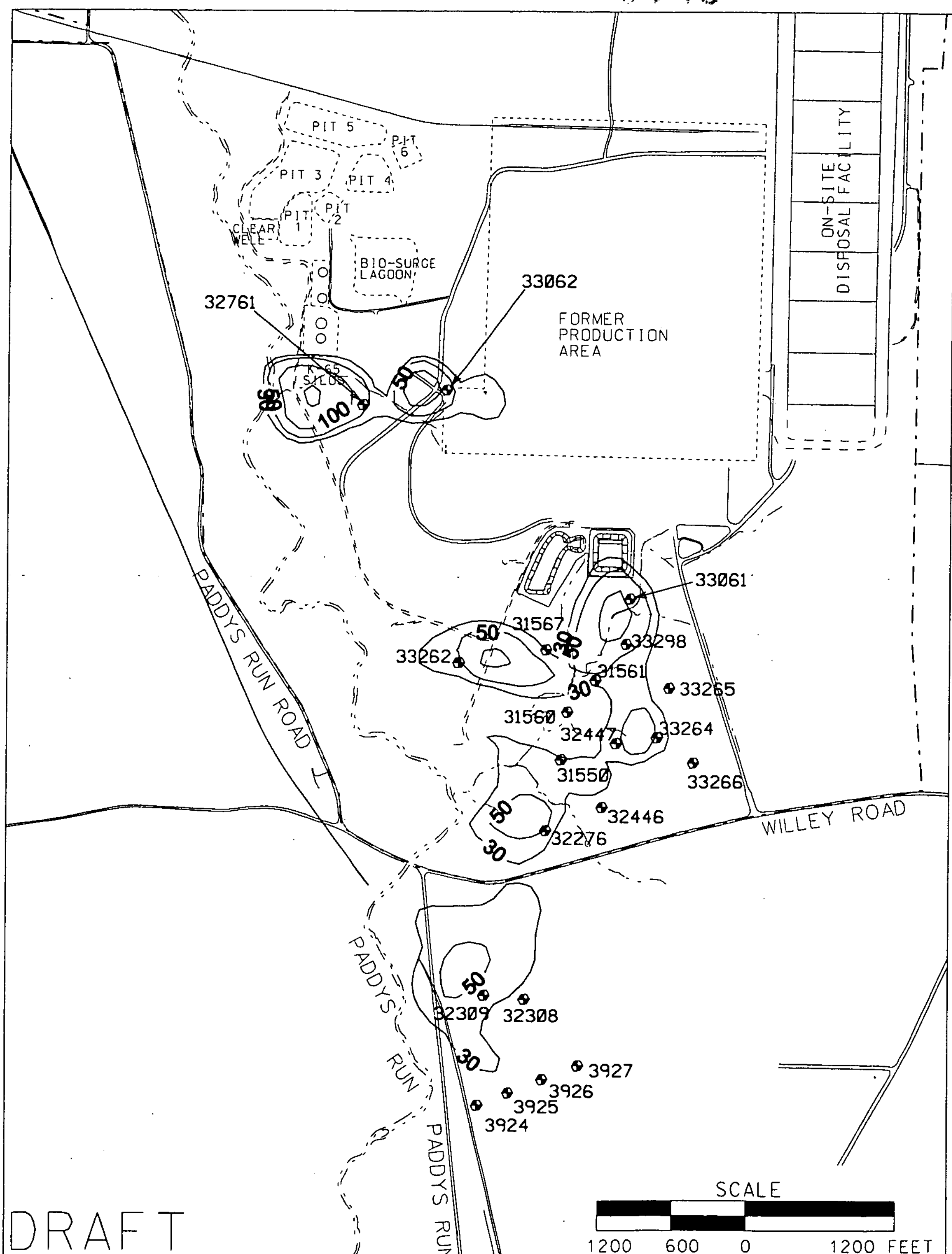
LEGEND:

FERNALD SITE BOUNDARY

TOTAL URANIUM CONTOUR

EXTRACTION WELL

FIGURE 2.2.12. MODEL LAYER 11, PLUME AT 4-1-2006, FOR APPROACH C



LEGEND:

- FERNALD SITE BOUNDARY
- TOTAL URANIUM CONTOUR
- EXTRACTION WELL

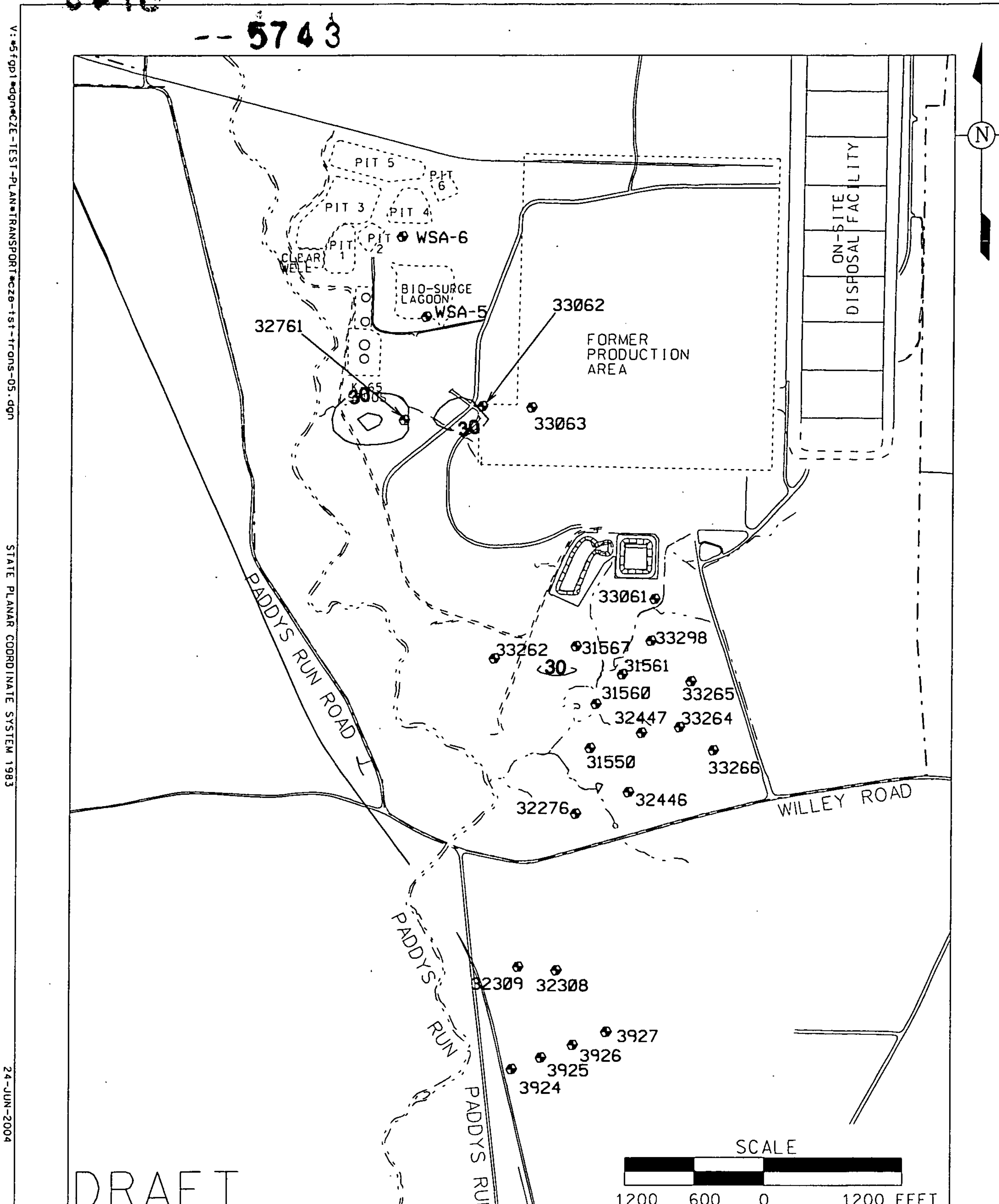
FIGURE 2.2.13. MODEL LAYER 12, PLUME AT 4-1-2006, FOR APPROACH C

v:\5fop1\dgn\CZE-TEST-PLAN\TRANSPORT\cze-tst-trans-09.dgn

STATE PLANAR COORDINATE SYSTEM 1983

24-JUN-2004

5743



LEGEND:

FERNALD SITE BOUNDARY
TOTAL URANIUM CONTOUR
EXTRACTION WELL

FIGURE 2.2.14. MODEL LAYER 11, PLUME AT 4-1-2012, FOR APPROACH C

5743

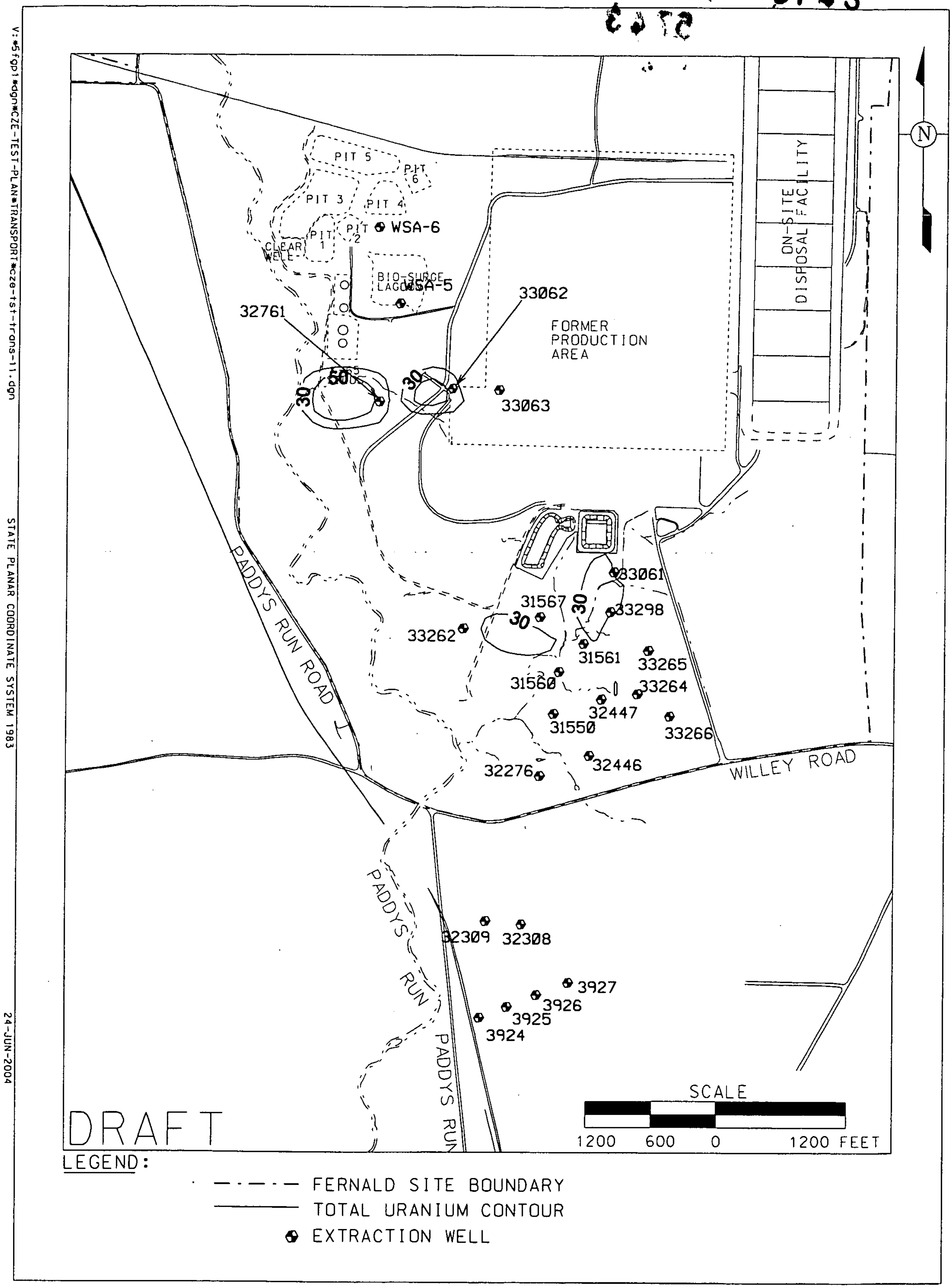


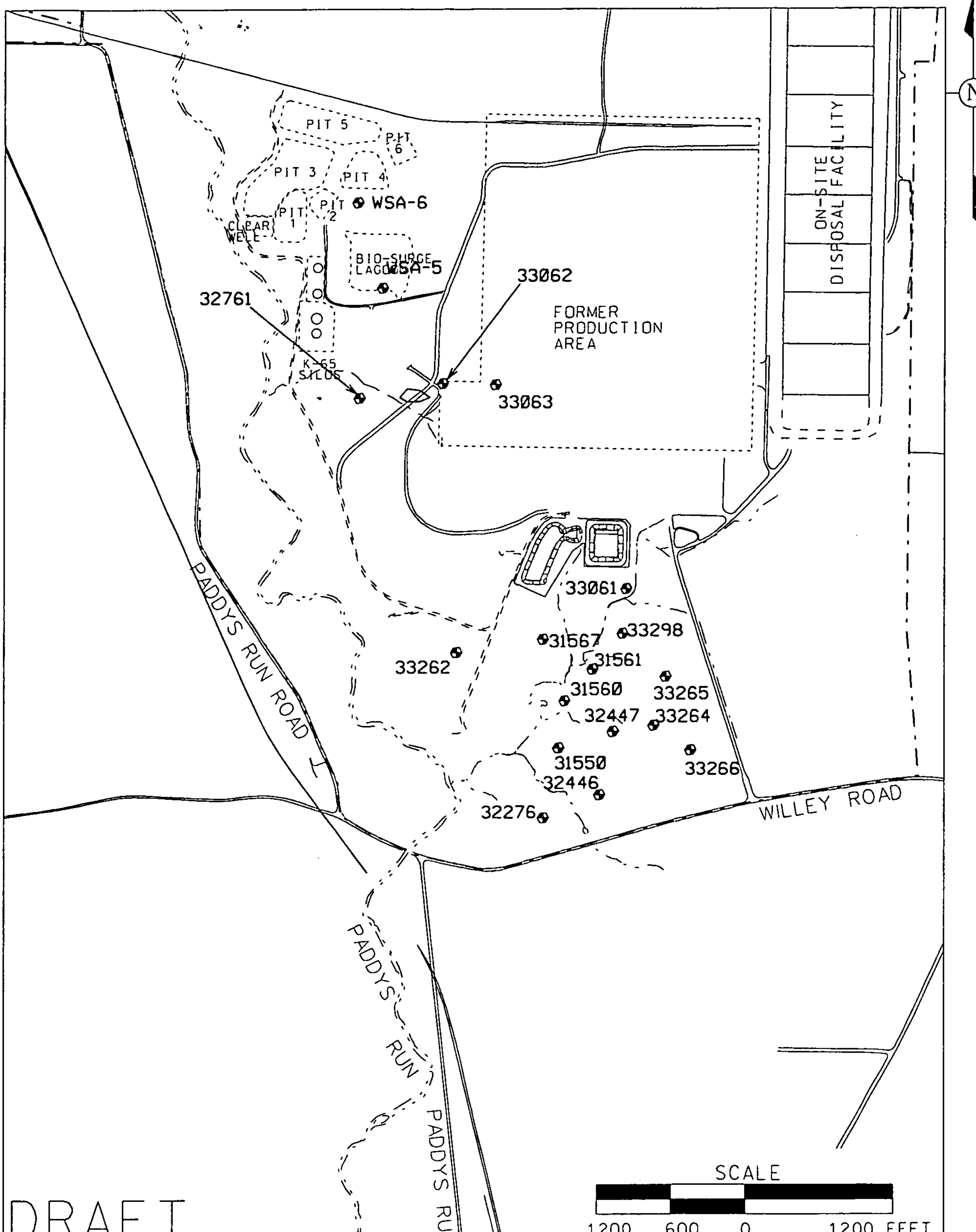
FIGURE 2.2.15. MODEL LAYER 12, PLUME AT 4-1-2012, FOR APPROACH C

5743

V:\5fgp1\dgn\CZE-TEST-PLAN\TRANSPORT\cze-tst-trans-13.dgn

STATE PLANAR COORDINATE SYSTEM 1983

24-JUN-2004



LEGEND:

- –·–·– FERNALD SITE BOUNDARY
- ——— TOTAL URANIUM CONTOUR
- ⊕ EXTRACTION WELL

FIGURE 2.2.16. MODEL LAYER 12, PLUME AT 4-1-2020, FOR APPROACH C

3.0 AQUIFER REMEDY WITH INDUCED RECHARGE THROUGH THE SSOD

For modeling purposes, this approach is referred to as Approach C-Improved. Approach C-Improved enhances Approach C by adding 500 gpm of additional recharge down the SSOD. If implemented, groundwater pumped from construction wells, located on the east side of the Fernald Site property, would be conveyed to the head of the northeastern fork of the SSOD and allowed to flow into the SSOD at a rate of 500 gpm see Figure 3.1.

Approach C-Improved is also based on a groundwater treatment capacity of 800 gpm. As discussed in Section 2 for Approach C, Approach C-Improved cannot serve as a final design for the remedy, but it can be used to demonstrate how the remedy will respond if an induced recharge of 500 gpm through the SSOD is added to the clean-up operation.

3.1 FLOW MODEL RESULTS

The procedure used to model flow in Approach C was also used for Approach C-Improved. The large VAM3D model was used to set boundary conditions for the smaller zoom model. For each pumping time period, the large VAM3D model was run to steady state. Steady state head values from the large model at nodes closest to the zoom model boundary nodes were assigned to the zoom model using a FORTRAN program. The zoom model was then run to steady state with the constant head boundaries derived from the larger model.

Pumping rates for Approach C-Improved are provided in Table 3.1.1. The first two pumping periods (1-1-04 to 10-1-04 and 10-1-04 to 4-1-05) have the same pumping rates as those defined for Approach C (see Section 2). Pumping rates in the last three time periods differ from those defined for Approach C in that Approach C-Improved contains induced recharge through the SSOD at a rate of 500 gpm and some higher pumping rates. The pumping rates in the last three pumping periods of Approach C-Improved are higher than the last three pumping periods of Approach-C because induced recharge into the SSOD allows more pumping from the aquifer without increasing the net extraction rate from the aquifer.

Predicted groundwater elevations for the Approach C-Improved design are shown for nominal boundary conditions in Figures 3.1.1 through 3.1.3 for the last three pumping periods for Approach C-Improved, Model Layer 12. Figures 3.1.4 through 3.1.6 show 10-year time-of-travel, non-retarded, particle paths for the last three pumping periods. The particles modeled for these figures were seeded in the same manner as for Approach C. The 30 μg/L uranium plume shown in Figures 3.1.4 through 3.1.5 is the same maximum uranium plume shown for Approach C. The particle path figures illustrate capture at the edge of the 30 μg/L uranium plume, at 510 feet amsl, throughout the life of the aquifer remedy using the pumping rates defined for Approach C-Improved. Using the 2003 maximum plume definition to illustrate capture throughout the life of the remedy is conservative, in that the plume footprint will actually decrease as the cleanup proceeds. As discussed in Section 2.2, under Approach C the South Plume, south of Willey Road, will be remediated by the year 2012, at which time pumping from the South Plume Wells will end. Therefore, Figure 3.1.6 (for time period 2012 to the end of the remedy) illustrates capture using the model predicted 30 μg/L uranium plume for the year 2012.

3.2 TRANSPORT MODEL RESULTS

VAM3D transport model scenarios were run to estimate how the Approach C-Improved Design would perform given the observed aquifer concentrations (initial conditions) and the contaminant source terms remaining. Transport runs were made with all three sets of boundary conditions corresponding to nominal, wet, and dry periods. As in Approach C, a constant Kd of 3.0 L/kg was used for all groundwater model transport runs. A Kd of 3 L/kg was also used in the Comprehensive Groundwater Strategy Report. Additional information concerning the use of a Kd of 3 L/kg is provided in the Comprehensive Groundwater Strategy Report.

3.2.1 Initial Conditions

The same initial conditions used for Approach C were also used for Approach C-Improved. See Section 2 for more details.

3.2.2 Transport Model Source Terms

Source terms for Approach C-Improved were the same as those used for Approach C, with the exception of the SSOD. A conservative source term of 5 parts per billion was used for the water being injected into the SSOD beginning in 4-1-05 and proceeding until the end of the remedy. A 500-gpm recharge in the SSOD was simulated in the VAM3D model by increasing the recharge by 50 gpm at each of the ten model nodes along the SSOD (Figure 3.2.1), and at the model's top surface. Selection of these nodes in the model corresponds to the approximate location in the SSOD where the glacial overburden is no longer present (OU5 Remedial Investigation Report, Figure 3-26).

3.2.3 Predicted Total Uranium Concentrations

Figures 3.2.2 through 3.2.6 show predicted total uranium concentrations in zoom Model Layers 11 and 12 at the end of the last three pumping periods of Approach C-Improved. The model was run with nominal flow boundary conditions corresponding to the October 1998 calibration conditions. As shown in Figure 3.2.6, the total uranium concentrations in the aquifer in 2020 are below 30 µg/L except in a small area near the Pilot Plant Drainage Ditch. Total uranium concentrations in this area drops below 30 µg/L between 2021 and 2022. Concentrations are shown in zoom Model Layers 11 and 12 because these two layers contain most of the 30 µg/L uranium plume.

3.2.4 Ability to Meet Discharge Limits at the Parshall Flume

The ability to meet discharge limits at the Parshall Flume was assessed using "Test Pump". Test Pump is an excel spreadsheet that calculates a flow weighted discharge concentration based on pre-defined treatment capabilities, extraction well uranium concentrations, and pumping rates. Table 5.3 illustrates that the discharge limits will not be met during the CAWWT construction time period. The blended outfall concentration is predicted to be 30.6 µg/L and the mass of uranium per year to the river is predicted to be 802 pounds.

3.3 APPROACH C-IMPROVED MODELING CONCLUSIONS

Modeling results indicate that the OU5 ROD established target-pumping rate of 4000 gpm can be met or exceeded using Approach C-Improved. Table 3.1.1 lists pumping rates for Approach C-Improved. The lowest net extraction rate for Approach C-Improved is 4565 gpm.

Modeling results indicate that the OU5 ROD established discharge limits would not be met with pumping rates defined for Approach C-Improved when the CAWWT is operational. This reflects a modeled groundwater treatment capacity of 800 gpm; when 1200+ gpm will actually be available. The field verification exercise in Section 5 will be used to demonstrate what pumping rates should be used for Approach C-Improved that will achieve best capture of the 30 µg/L uranium plume. Once these new rates are modeled using 1200+ gpm treatment capacity it is felt that discharge limits will be safely met.

Particle path figures predict capture of the 30 µg/L uranium plume throughout the life of the aquifer remedy using the pumping rates defined for Approach C-Improved. These results are considered conservative in that Approach C-Improved only provides for 800 gpm groundwater treatment and up to 1800 gpm will actually be available. This means that higher pumping rates could actually be achieved which should increase capture.

Modeled aquifer cleanup for Approach C-Improved occurs between 2021 and 2022.

It is unknown if the SSOD is capable of delivering 500 gpm recharge to the aquifer, or if some or most of the flow would just be carried off through the SSOD and into Paddys Run. Actual volumes of recharge will be quantified via the field verification plan presented in Section 5.

Direct comparison of results from Approach C-Improved to results presented in the Comprehensive Groundwater Strategy Report should take into consideration that initial conditions and Kriging used for Approach C-Improved have changed from what was used in the Comprehensive Groundwater Strategy Report.

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Table 3.1.1
Pumping Rates for Approach C-Improved

	Pumping Periods				
	1 1/1/04 to 10/1/04 (gpm)	2 10/1/04 to 4/1/05 (gpm)	3 4/1/05 to 4/1/06 (gpm)	4 4/4/06 to 4/1/12 (gpm)	5 4/1/12 to End (gpm)
SP 1 (3924)	300	300	200	200	0
SP 2 (3925)	300	300	200	200	0
SP 3 (3926)	300	300	200	200	0
SP 4 (3927)	400	400	400	400	0
SP Opt 6	300	300	200	200	0
SP Opt 7	300	300	200	200	0
Sub Total	1900	1900	1400	1400	0
SF 17	275	275	175	175	175
SF 18	200	200	100	100	100
SF 19	200	200	100	100	100
SF 20	200	200	100	100	400
SF 21	290	100	200	200	300
SF 22	300	300	300	300	400
SF 23	300	300	300	300	400
SF 24	300	100	300	300	300
SF 25	300	300	400	400	400
SF 31	200	100	200	200	300
SF 32	300	100	400	400	400
SF 33	300	300	400	400	400
SF 34	200	200	400	400	400
Sub Total	3365	2675	3375	3375	4075
WSA 1	300	0	300	300	500
WSA 2	400	0	200	200	200
WSA 4	0	0	0	200	200
WSA 5	0	0	0	100	100
WSA 6	0	0	0	100	100
Sub Total	700	0	500	900	1100
Total Extraction	5965	4575	5275	5675	5175
IW 8A	200	0	0	0	0
IW 9A	200	0	0	0	0
IW 10	200	0	0	0	0
IW 10A	200	0	0	0	0
IW 11	200	0	0	0	0
SF 16	200	0	0	0	0
SF INJ 1	100	0	0	0	0
BASINS	100	0	0	0	0
SSOD	0	0	500	500	500
Total Re-injection	1400	0	500	500	500
Net Extraction	4565	4575	4775	5175	4675

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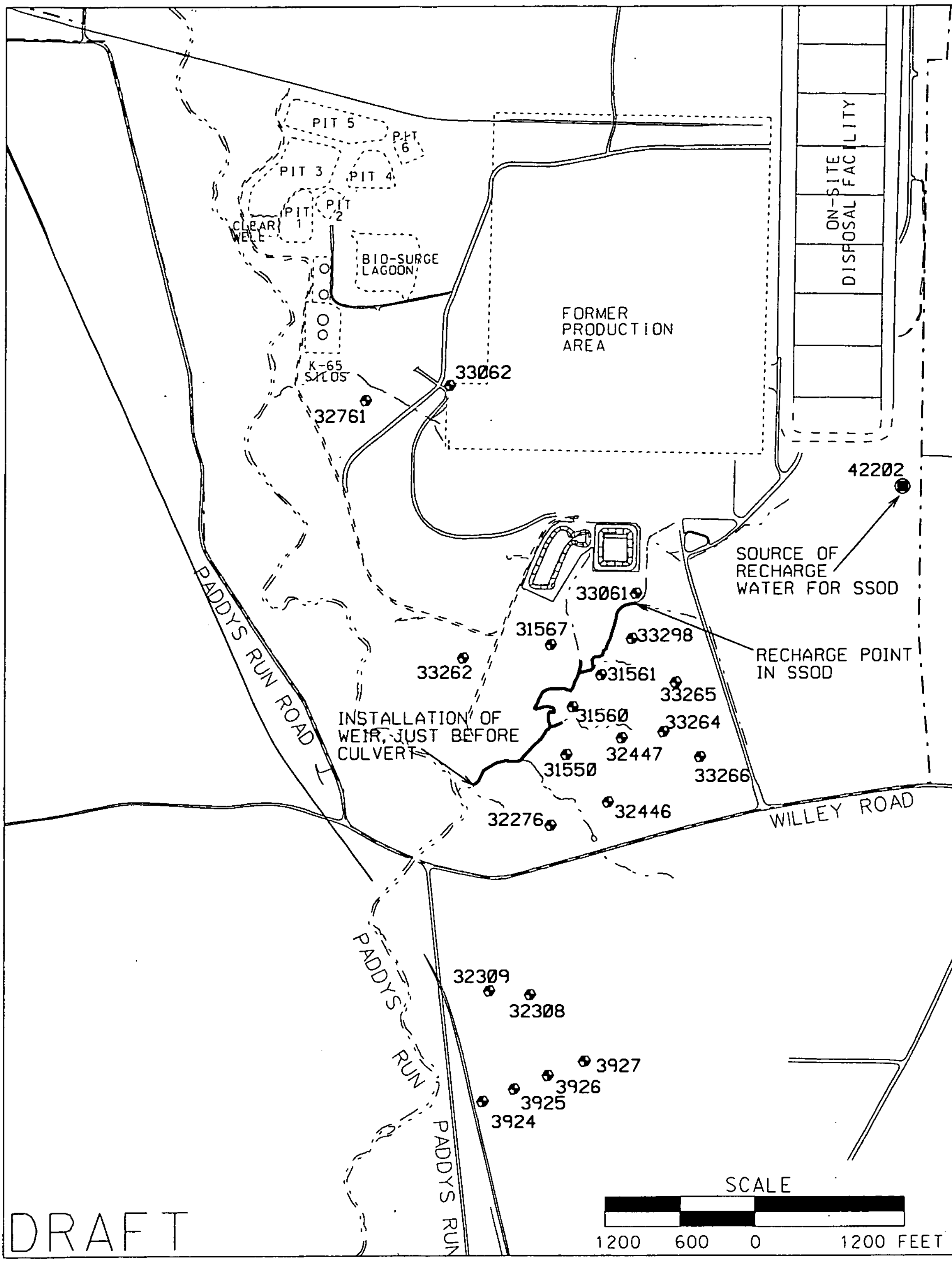


LEGEND:

- ·—·— FERNALD SITE BOUNDARY
- —— SSOD
- ⊕ EXTRACTION WELL

V:\5fgp1\dgn\CZE-TEST-PLAN\cze-test-18.dgn

STATE PLANAR COORDINATE SYSTEM 1983

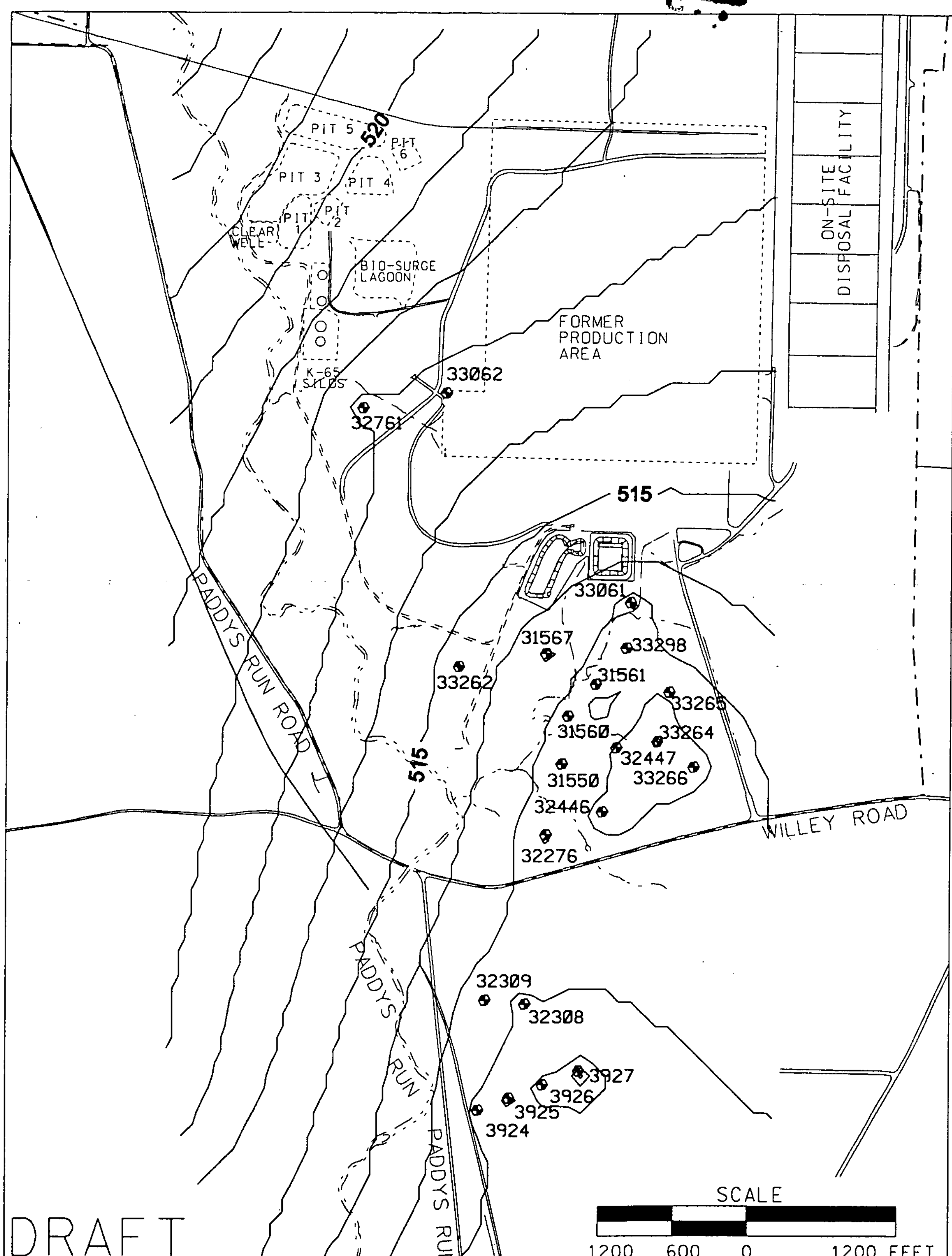
24-JUN-2004

FIGURE 3.1. LOCATION MAP FOR APPROACH C-IMPROVED FIELD VERIFICATION

V:*5fgp1*dgn*CZE-TEST-PLAN*GW*cze-tst-gw-05.dgn

STATE PLANAR COORDINATE SYSTEM 1983

22-JUN-2004



LEGEND:

- FERNALD SITE BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- EXTRACTION WELL

FIGURE 3.1.1. MODELED GROUNDWATER ELEVATION PREDICTIONS, 4-1-2005 TO 4-1-2006, APPROACH C-IMPROVED

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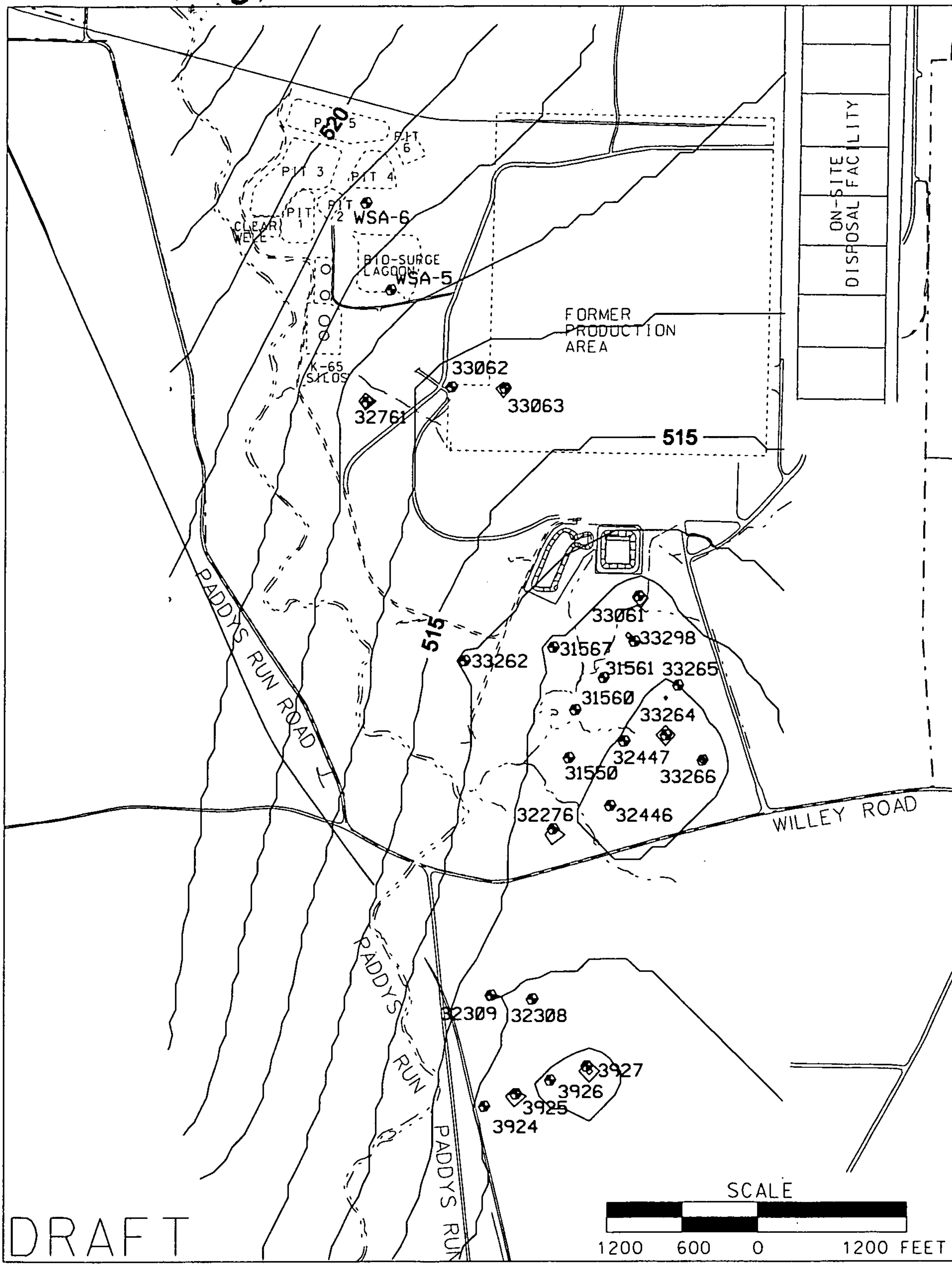
V:*5fgp1*dgn*CZE-TEST-PLAN*GW*cze-tst-gw-04.dgn

STATE PLANAR COORDINATE SYSTEM 1983

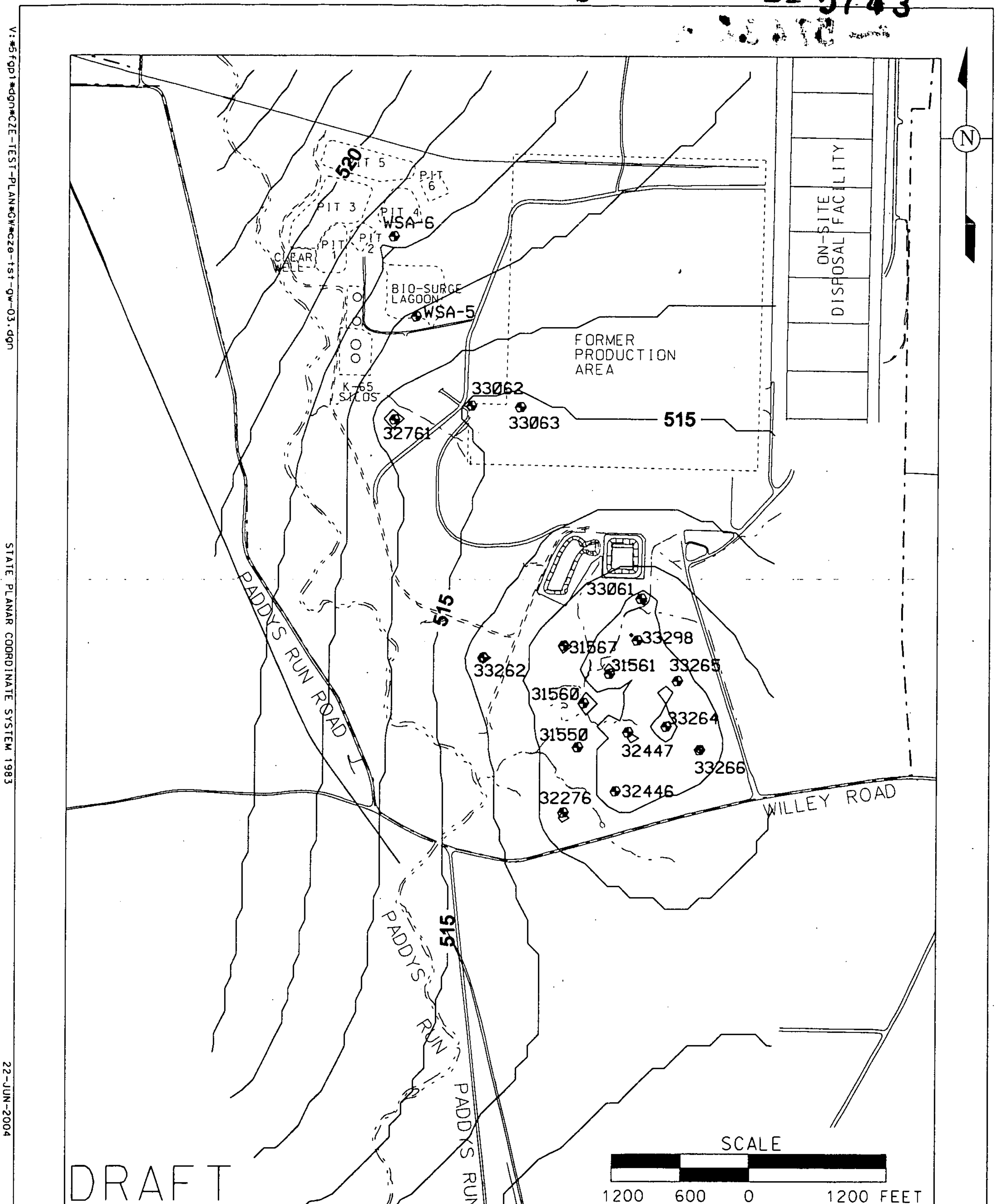
22-JUN-2004



LEGEND:

- · - · - FERNALD SITE BOUNDARY
——— GROUNDWATER ELEVATION CONTOUR
⊕ EXTRACTION WELL

FIGURE 3.1.2. MODELED GROUNDWATER ELEVATION PREDICTIONS, 4-1-2006 TO 4-1-2012, APPROACH C-IMPROVED

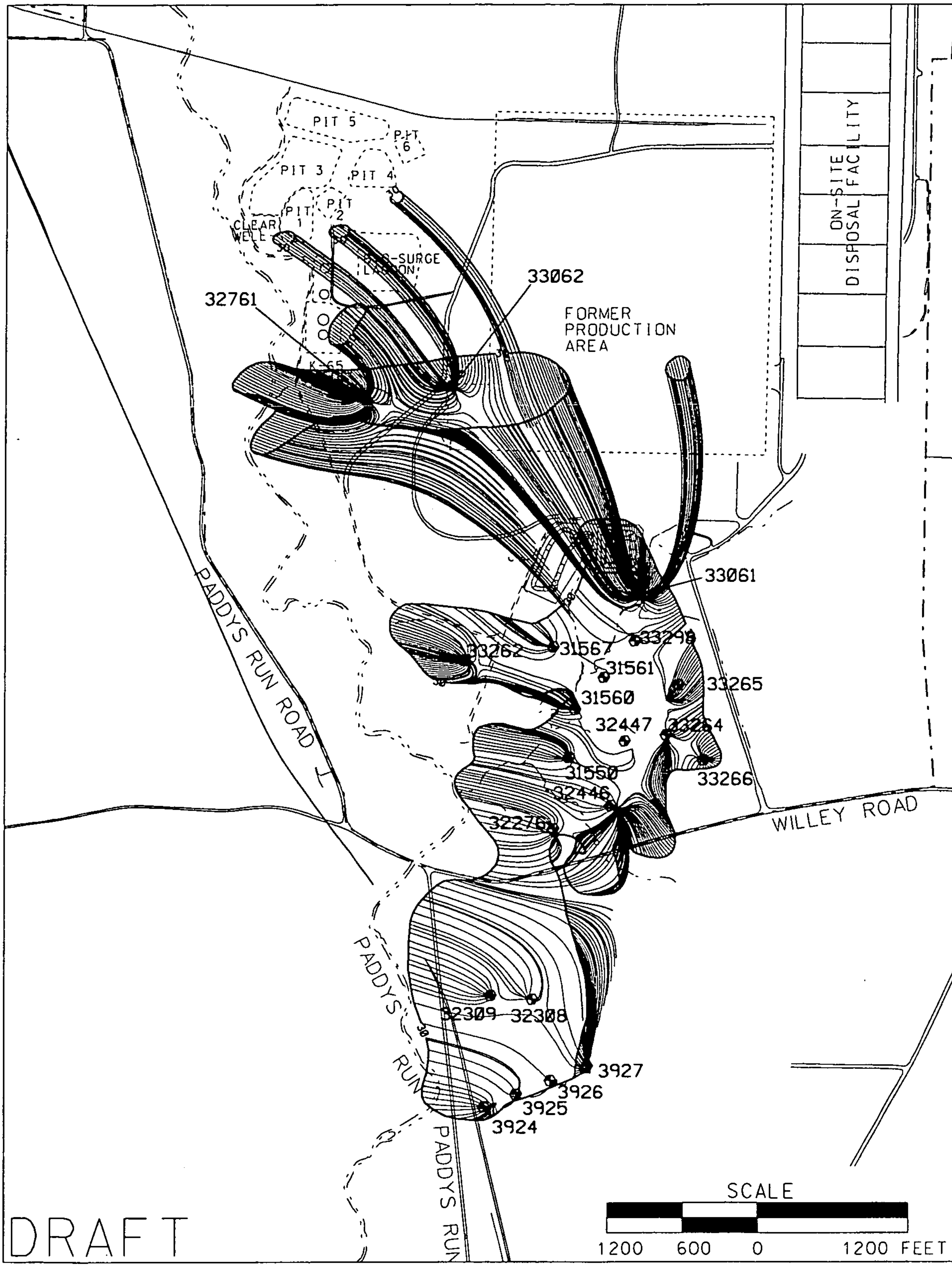


LEGEND:

- — · — · — FERNALD SITE BOUNDARY
- ———— GROUNDWATER ELEVATION CONTOUR
- EXTRACTION WELL

FIGURE 3.1.3. MODELED GROUNDWATER ELEVATION PREDICTIONS, 4-1-2012 TO END, APPROACH C-IMPROVED

5743



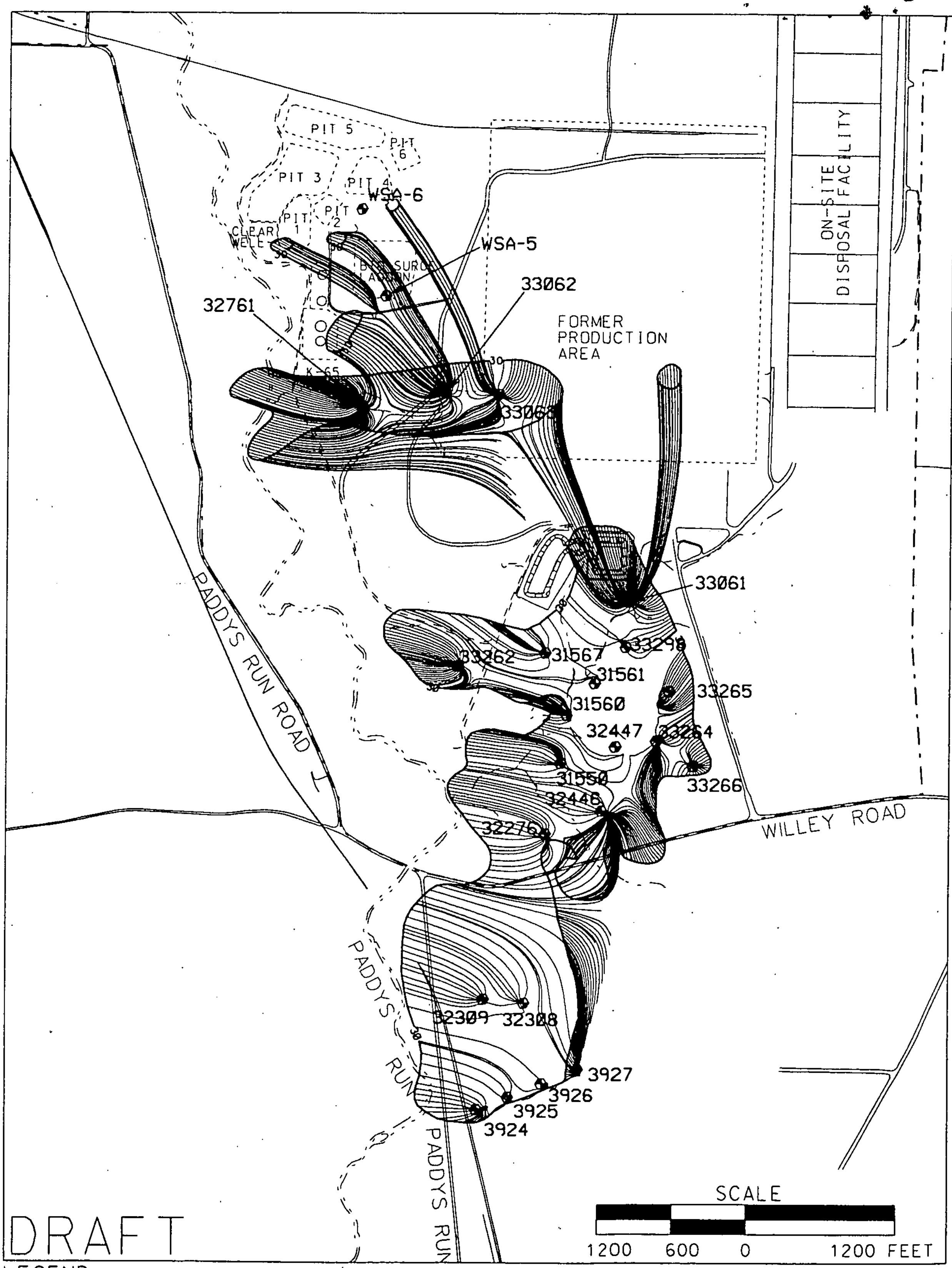
STATE PLANAR COORDINATE SYSTEM 1983

22-JUN-2004

LEGEND:

- FERNALD SITE BOUNDARY
- PARTICLE TRACK
- EXTRACTION WELL
- TOTAL URANIUM CONTOUR (30 μg/L) THROUGH SECOND HALF OF 2003

FIGURE 3.1.4. 10-YEAR, NON-RETARDED PARTICLE TRACKS FROM PLUME BOUNDARY, APPROACH C-IMPROVED, 4-1-2005 TO 4-1-2006



V:*5fgpl*dgn*CZE-TEST-PLAN*cze-test-06.dgn

STATE PLANAR COORDINATE SYSTEM 1983

22-JUN-2004

LEGEND:

- FERNALD SITE BOUNDARY
- PARTICLE TRACK
- EXTRACTION WELL
- 30 TOTAL URANIUM CONTOUR (30 μg/L) THROUGH SECOND HALF OF 2003

FIGURE 3.1.5. 10-YEAR, NON-RETARDED PARTICLE TRACKS FROM PLUME BOUNDARY, APPROACH C-IMPROVED, 4-1-2006 TO 4-1-2012

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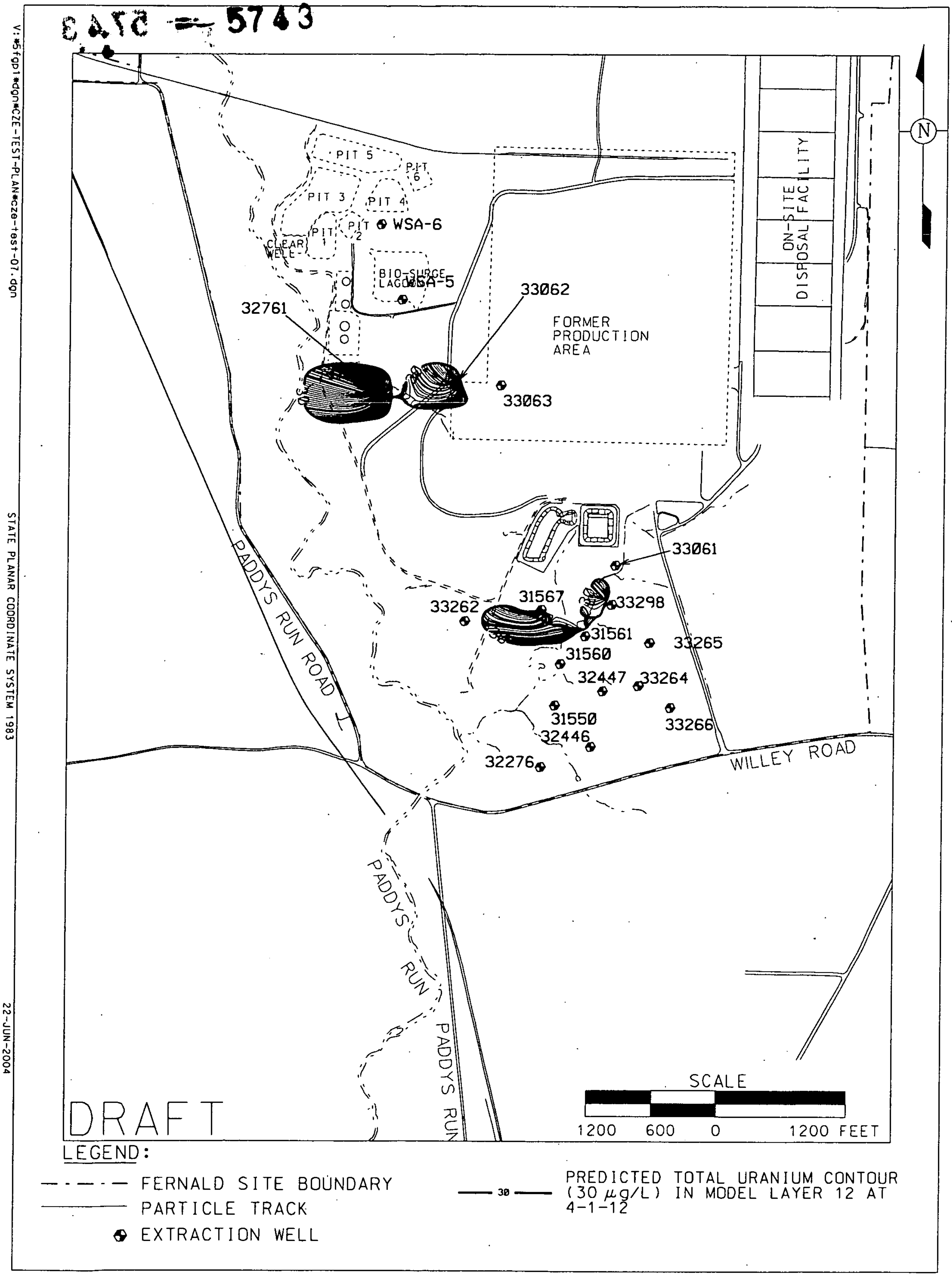


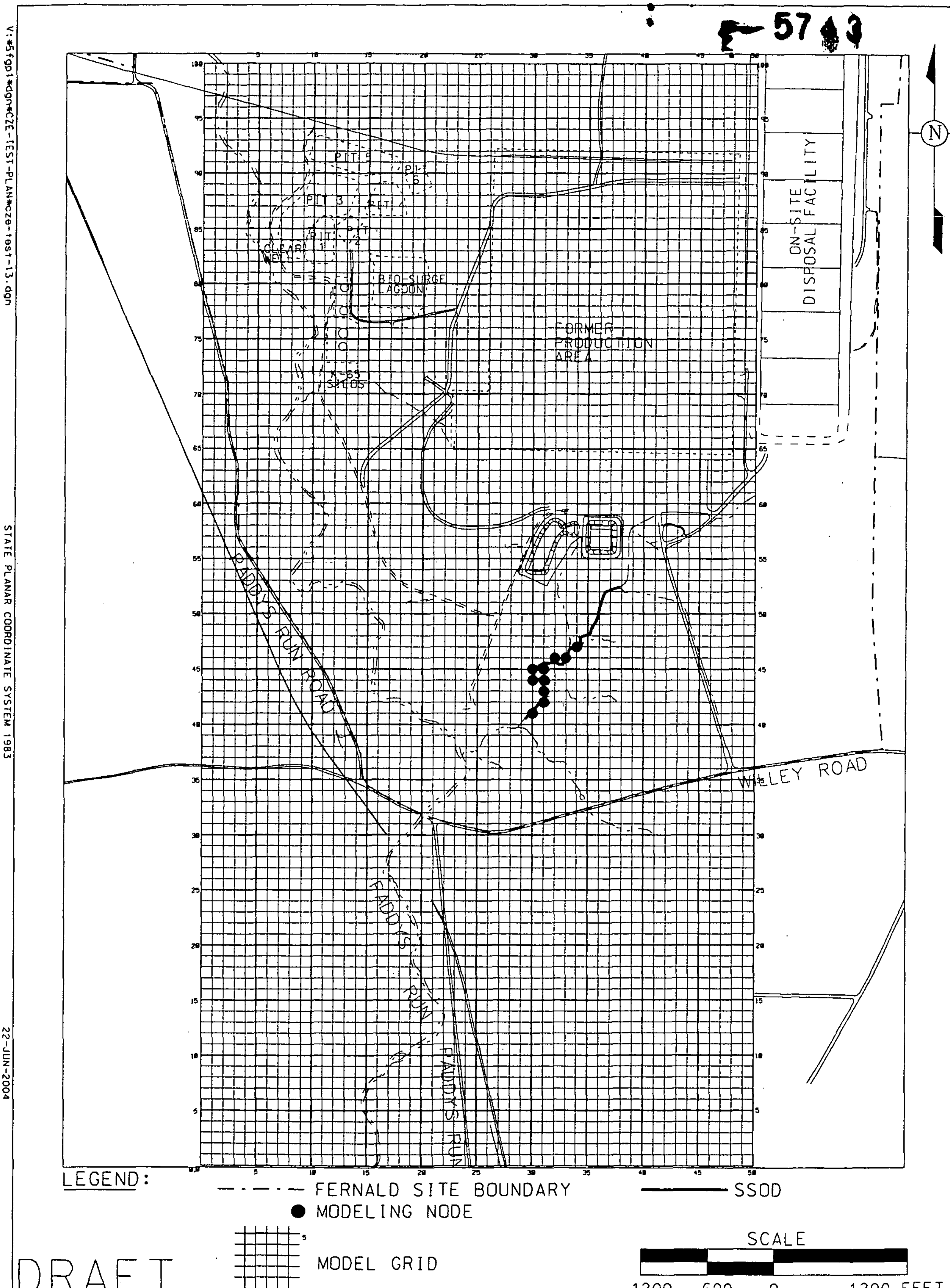
V:*5fgp1*dgn*CZE-TEST-PLAN*cze-test-07.dgn

STATE PLANAR COORDINATE SYSTEM 1983

22-JUN-2004

FIGURE 3.1.6. 10-YEAR, NON-RETARDED PARTICLE TRACKS FROM PLUME BOUNDARY, APPROACH C-IMPROVED, 4-1-2012 TO END

5743



V:\5fgpi\dgn\CZE-TEST-PLAN\cze-test-13.dgn

STATE PLANAR COORDINATE SYSTEM 1983

22-JUN-2004

FIGURE 3.2.1. MODEL BLOCKS USED FOR SSOD RECHARGE

5743

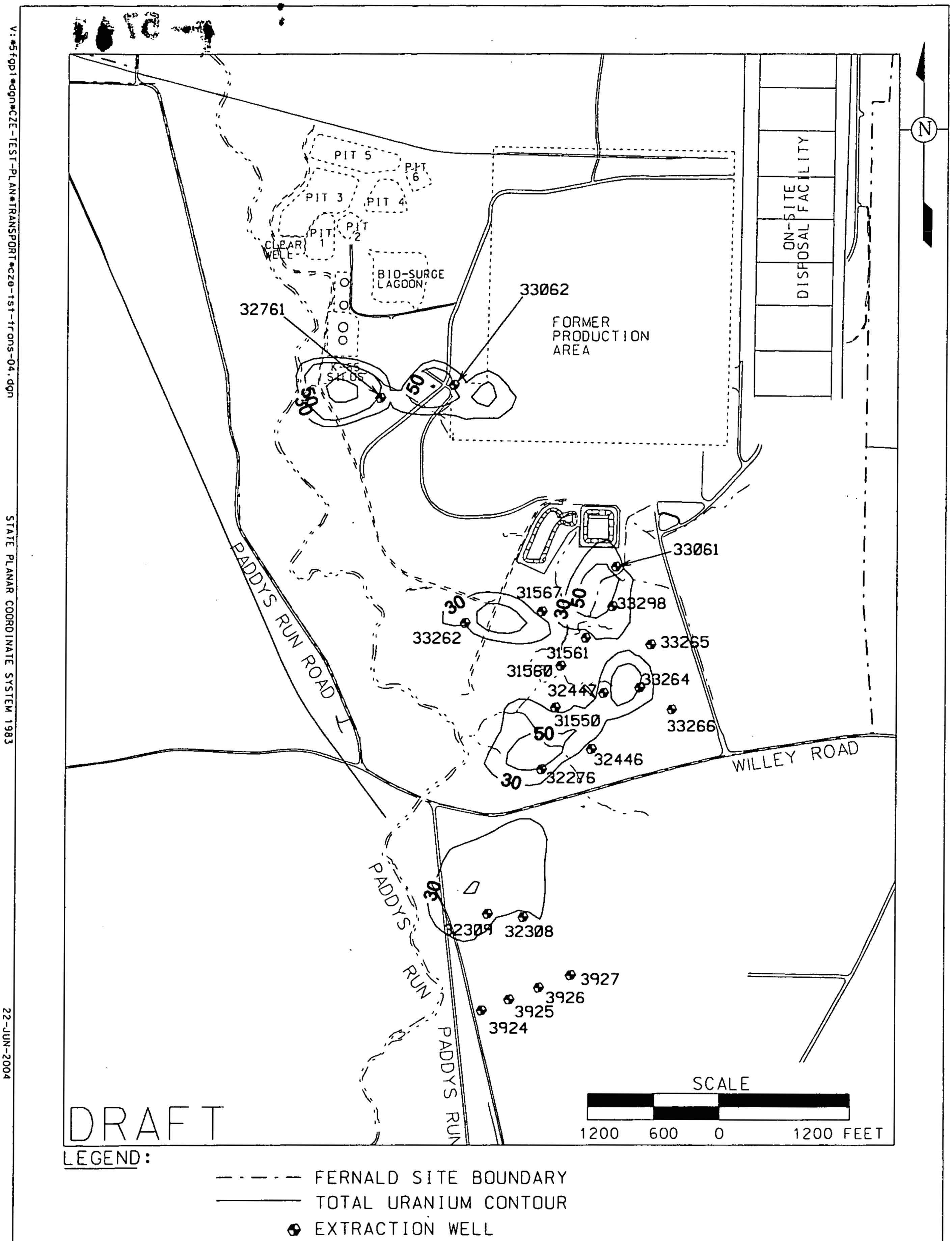


FIGURE 3.2.2. MODEL LAYER 11, PLUME AT 4-1-2006, FOR APPROACH C-IMPROVED

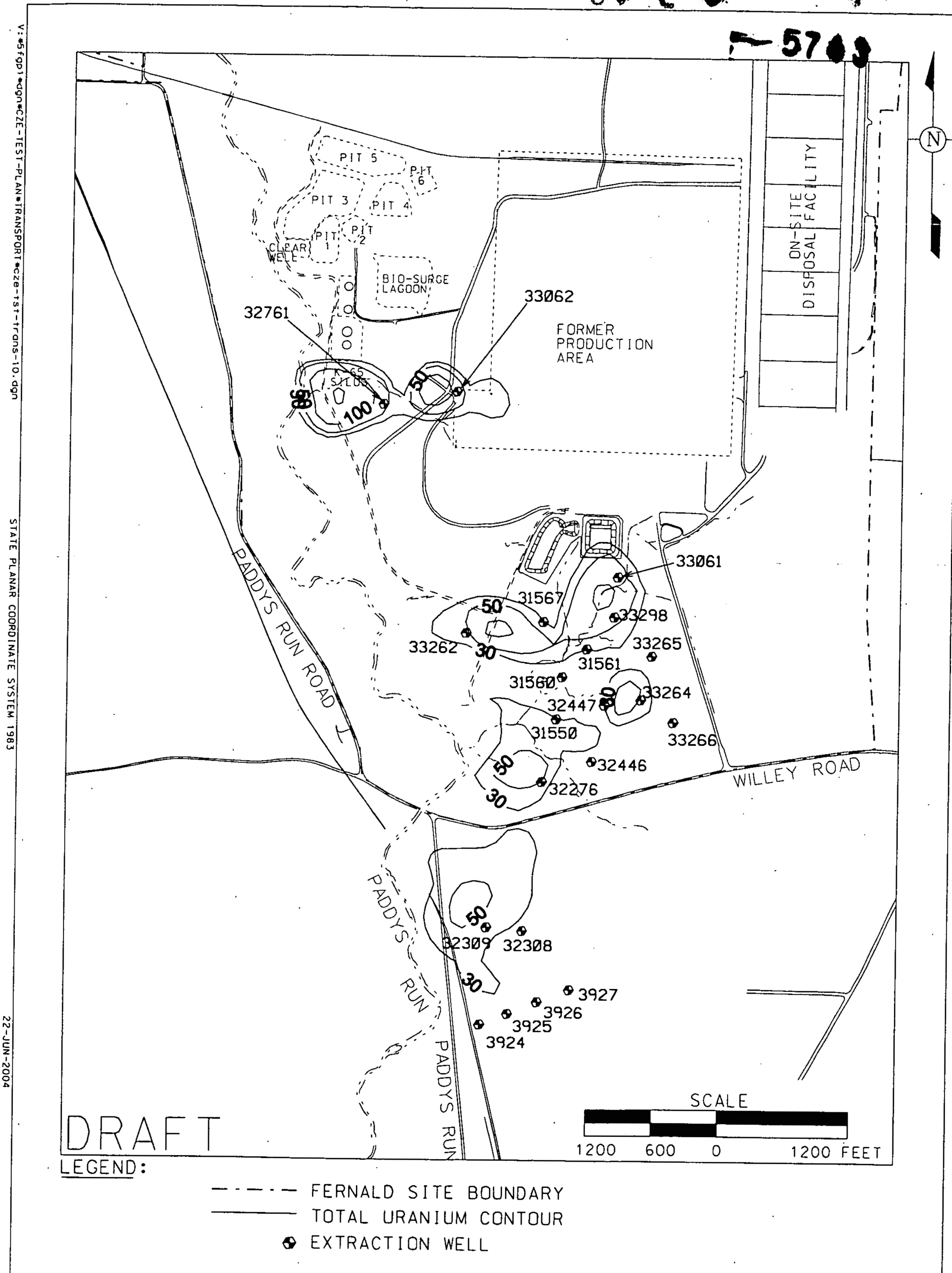


FIGURE 3.2.3. MODEL LAYER 12, PLUME AT 4-1-2006, FOR APPROACH C-IMPROVED

V:*5fgp1*dgn*CZE-TEST-PLAN*TRANSPORT*cze-tst-trans-10.dgn

STATE PLANAR COORDINATE SYSTEM 1983

22-JUN-2004

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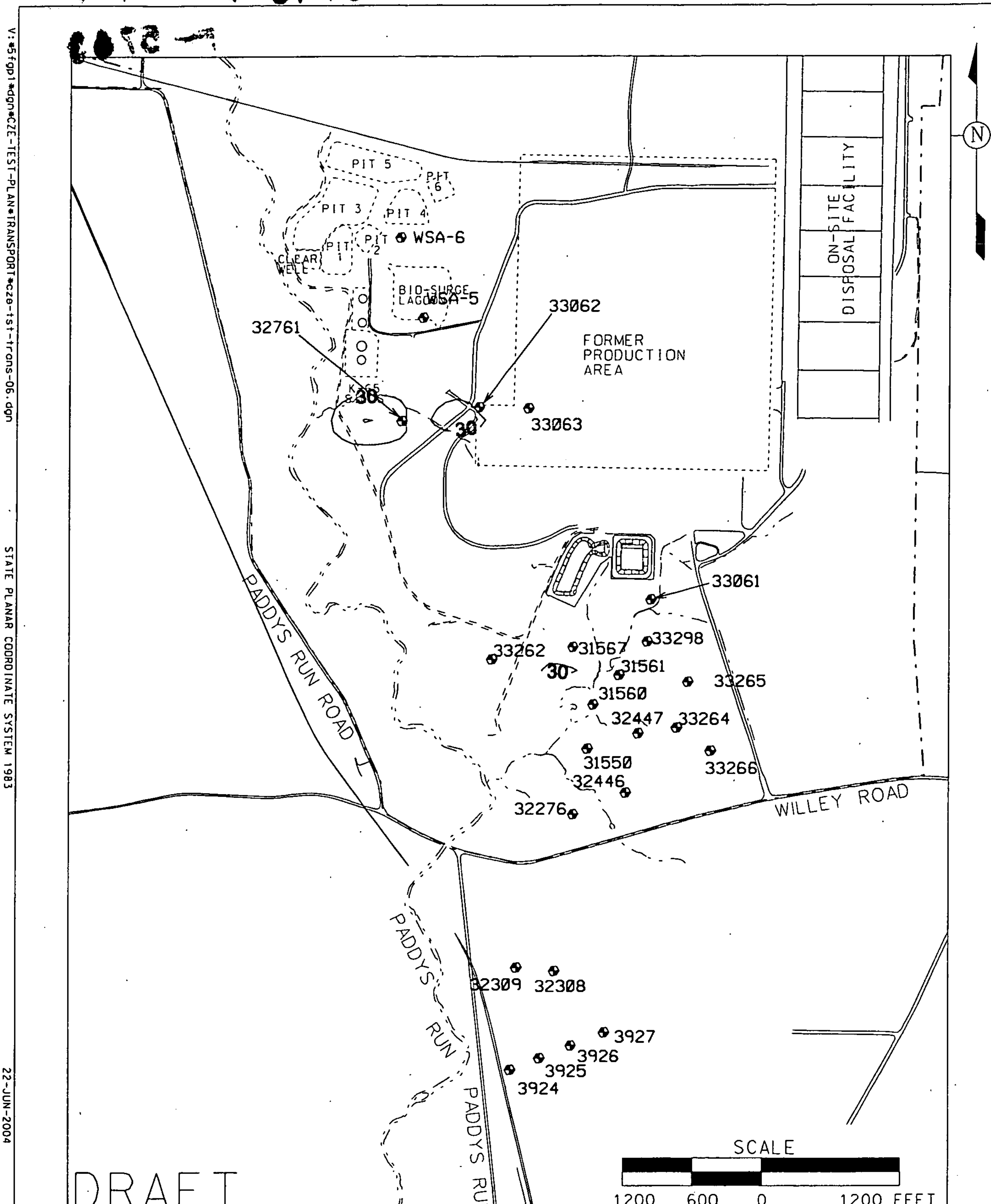
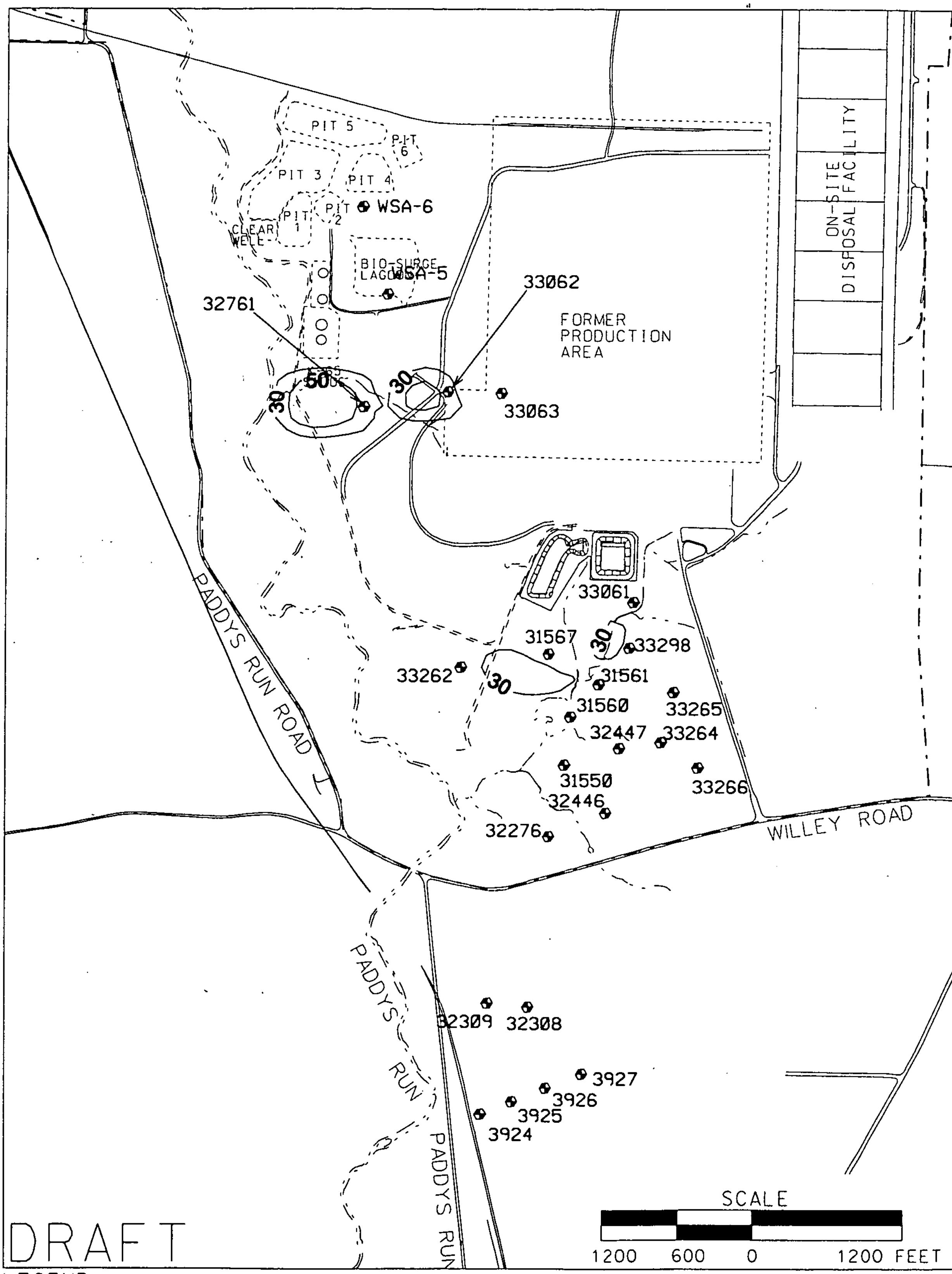


LEGEND:

FERNALD SITE BOUNDARY
TOTAL URANIUM CONTOUR
EXTRACTION WELL

FIGURE 3.2.4. MODEL LAYER 11, PLUME AT 4-1-2012, FOR APPROACH C-IMPROVED



LEGEND:

- —·—·— FERNALD SITE BOUNDARY
- ——— TOTAL URANIUM CONTOUR
- EXTRACTION WELL

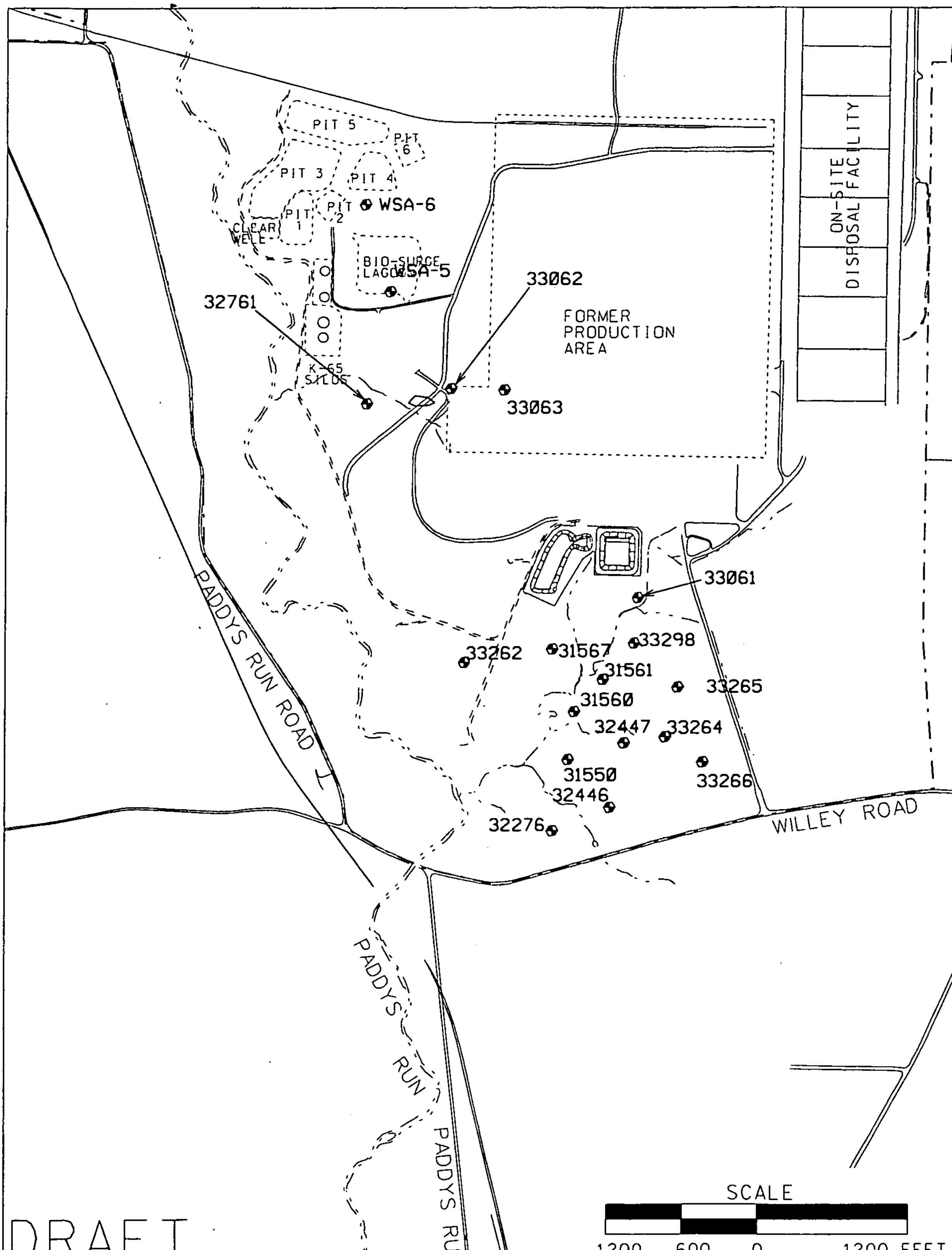
FIGURE 3.2.5. MODEL LAYER 12, PLUME AT 4-1-2012, FOR APPROACH C-IMPROVED

V:*5fgp1*dgn*CZE-TEST-PLAN*TRANSPORT*cze-tst-trans-12.dgn

STATE PLANAR COORDINATE SYSTEM 1983

22-JUN-2004

5743



LEGEND:

- — · — · — FERNALD SITE BOUNDARY
- ———— TOTAL URANIUM CONTOUR
- ⊕ EXTRACTION WELL

V:\5fgp1\dgn\CZE-TEST-PLAN\TRANSPORT\cze-tst-trans-14.dgn

STATE PLANAR COORDINATE SYSTEM 1983

22-JUN-2004

FIGURE 3.2.6. MODEL LAYER 12, PLUME AT 4-1-2020, FOR APPROACH C-IMPROVED

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

- Modeling results indicate that the OU5 ROD established target-pumping rate of 4000 gpm can be met or exceeded using either Approach C or Approach C-Improved.

- Modeling results indicate that the OU5 ROD established discharge limits can be met with pumping rates defined for Approach C.

- Modeling results indicate that the OU5 ROD established discharge limits will not be met with pumping rates defined for Approach C-Improved during the period from 4-1-05 to 4-1-06. This reflects a modeled groundwater treatment capacity of 800 gpm though, when 1200+ gpm will actually be available. The field verification exercise in Section 5 will be used to demonstrate what pumping rates should be used for Approach C-Improved during this time period to achieve best capture of the 30 μg/L uranium plume. Once these new rates are modeled using 1200+ gpm treatment capacity the prediction should be that discharge limits will be safely met. However, pumping rates will be adjusted if necessary to meet discharge limits at the Parshall Flume.

- Table 4.1.1 presents cleanup times predicted for each approach. Comparison of Alternatives 1 and 6 from the Comprehensive Groundwater Strategy Report indicates that stopping well-based re-injection will increase overall cleanup times by three years.

- Without well-based re-injection (Approach C) predicted cleanup of the aquifer occurs between 2022 and 2023. If induced recharge down the SSOD at a rate of 500 gpm is added to the remedy (Approach C-Improved) predicted cleanup occurs between 2021 and 2022. Adding induced recharge down the SSOD at a rate of 500 gpm to the remedy decreases the predicted clean up time by one year

- Comparison of results from either Approach C or C-Improved to results presented in the Comprehensive Groundwater Strategy Report should take into consideration that initial conditions and Kriging used for Approach C and C-Improved have changed from what was used for modeling done in support of the Comprehensive Groundwater Strategy Report.

- Particle track figures for Approach C and Approach C-Improved predict that capture of the 30 μg/L uranium plume will be maintained throughout the life of the aquifer remedy without well-based re-injection and with or without induced recharge at a rate of 500 gpm through the SSOD.

- Because capture is predicted throughout the aquifer remedy for Approach C-Improved, it is concluded that pumping construction wells on the east side of the Fernald Site property to obtain recharge water for the SSOD will not detrimentally affect plume gradients and flow patterns associated with the aquifer remedy.

- It is unknown if the SSOD is capable of delivering 500 gpm recharge to the aquifer, or if some or most of the flow would just be carried off through the SSOD and into Paddys Run. Actual volume of recharge will be quantified via the field verification plan presented in Section 5.

- Modeling predicts that without reinjection along Willey Road pumping from the South Field Extraction wells will compete for water with pumping from the South Plume Optimization Wells, creating an area of stagnation. Particle track modeling indicates that when reinjection along Willey Road is discontinued, more attention will need to be given to the area during the remedy in order to disrupt the stagnation zone as much as possible through actions like pulsed pumping. Evaluation of this stagnation zone area is hindered due to its location being under private property and in an area with very few existing monitoring wells.

4.2 RECOMMENDATIONS

- Capture of the 30 µg/L uranium plume, without well based re-injection, should be verified in the field using pumping rates defined in the groundwater model for the time period when the CAWWT facility is under construction. The overall pumping rate would be 4575 gpm. If uranium plume capture is not verified, then pumping rates should be field adjusted in order to achieve on-property capture first, then off-property capture. Any field adjustments would be subject to treatment limitations in place during the testing period for maintaining uranium discharge limits at the Parshall Flume.

- Induced recharge at a rate of 500 gpm through the SSOD should be field verified to determine if such an operation is feasible. Given that the model indicates that 500 gpm recharge rate only shortens the remedy by approximately one year, it is doubtful that a recharge rate lower than 500 gpm would be beneficial. Therefore, if the SSOD is not capable of transmitting a minimum recharge rate of 500 gpm to the GMA, this operational approach should not be pursued. If induced recharge in the SSOD is not feasible, DOE will continue to evaluate other methods for improving remedy performance.

- Capture of the 30 µg/L uranium plume, without well based re-injection, but with 500 gpm induced recharge down the SSOD, should be verified in the field using pumping rates defined in Approach C-Improved for the first time interval when induced recharge is modeled (4-1-05 to 4-1-06). The total pumping rate would be 5275 gpm, but with induced recharge at a rate of 500 gpm, the net extraction rate is modeled at 4775 gpm. If uranium plume capture is not verified, then pumping rates should be field adjusted in order to achieve best on-property capture first, then best off-property capture. Any field adjustments would be subject to treatment limitations in place during the testing period for maintaining discharge limits at the Parshall Flume. Verifying capture under Approach C-Improved operational conditions will also verify that pumping the construction wells for a supply of induced recharge water for the SSOD does not have a detrimental impact on the aquifer remedy.

- When well-based re-injection is discontinued, special attention should be given to the area where stagnation is predicted. Lack of monitoring points in this area will hinder a detailed field verification of the presence of a stagnation area. Water level map interpretations should be used to try to define its presence. The installation of additional monitoring wells should be pursued, and a routine direct-push sampling effort should be defined and added to the Groundwater Remedy Performance Monitoring specified in the IEMP in order to more closely monitor restoration progress in this area.

- Information learned from the modeling presented in this document and the recommended field verification exercises defined above should be considered in the selection of a path forward for the aquifer remedy. Once an agreed to path is defined, a new design document should be issued with defined operational parameters.

F-5743

Table 4.1.1
Model Predicted Aquifer Clean Up Times

	GW Strategy Report [a]			
	Alternatives 1&2	Alternative 6	Approach C	Approach C-Improved
South Plume	2014-2015	2016-2017	2011-2012	2011-2012
South Field	2020-2021	2024-2025	2016-2017	2015-2016
Waste Storage Area	2021-2022	2022-2023	2022-2023	2021-2022

[a] Comparison of Alternatives 1 and 2 with Alternative 6 indicates that Re-injection shortens the remedy by 3 years.

Note: Comparison of Approach C with Approach C-Improved shows induced recharge down SSOD shortens remedy by 1 year.

Note: Direct comparison of clean up times from Approach C or Approach C-Improved with modeling results from GW strategy Report should take into consideration that initial conditions and Kriging used have changed.

5.0 FIELD VERIFICATION PLAN

Outlined below is a field verification plan to support the transition of groundwater remedy operations from an operational mode that included large-scale, well-based re-injection operations prior to the start of CAWWT construction, to a post CAWWT construction operational mode that does not include large-scale, well-based re-injection operations. The verification plan consists of two parts. Part I was initiated in September of 2004, as comment resolution for this plan was being finalized. Part II is scheduled for late 2004 early 2005.

Part I of the plan pertains to achieving capture of the 30 µg/L uranium plume without well-based re-injection. Large-scale, re-injection into the existing re-injection wells was stopped when construction of the CAWWT began in late September 2004. Pumping rates in the extraction wells were changed from rates defined in Pumping Period 1 (the period leading up to CAWWT construction) to rates defined in Pumping Period 2 (the period during CAWWT construction, see Tables 2.1.1 or 3.1.1). These two pumping periods are the same for both Approaches C and C-Improved.

Part II of the plan pertains to determining infiltration capabilities of the SSOD. The SSOD already receives seasonal flows of uncontrolled surface water runoff. Clean groundwater will be pumped into the SSOD to supplement the seasonal flows. Modeling predicts that enhancing recharge to the GMA through the SSOD will shorten the aquifer remedy by one year. Flows in the SSOD will be measured at key points to determine how much water is infiltrating into the subsurface.

Testing activities will include:

1) A baseline test that involves releasing 500 gpm of clean groundwater into the northeastern branch of the SSOD. If the SSOD is able to transmit this flow to the aquifer as recharge, operations could continue at a rate of 500 gpm and the beneficial impact to the aquifer remedy could be immediate.

2) Gauging of seasonal flows of water in the SSOD to gain a better understanding of how much of the seasonal flow infiltrates into the bed of the SSOD.

3) The possible use of infiltrometers at select locations along the bed of the SSOD to help measure and verify infiltration rates, and

4) Future flow testing that utilizes the entire SSOD (both northwestern and northeastern branches) to establish an optimal flow rate for enhancing recharge to the aquifer once remediation activities are complete in the northwestern branch.

Information learned from these field verification exercises will be used to:

- Establish new pumping rates for the groundwater remedy that result in best capture of the 30 µg/L total uranium plume, with enhanced recharge through the SSOD.
- Determine if recharge to the GMA through the SSOD at a rate of 500 gpm is feasible in the short term, and establish an optimal flow rate for the long term.
- Conduct additional groundwater modeling that incorporates field verification results.

Part I - Verification of plume capture after stopping well-based re-injection

On September 24, 2004, large-scale well-based re-injection was stopped, and pumping rates defined for the CAWWT construction time period were implemented. During CAWWT construction only 1300 gpm of water treatment is available, 700 gpm of this capacity is available to treat groundwater. As discussed with EPA and OEPA, if high inventories of storm water/remediation wastewater are experienced the groundwater treatment capacity may be reduced to as low as 200 gpm.

Pumping rates for this time period were determined from the Testpump excel spreadsheet, which calculates a blended average outfall concentration given input of pumping rates, treatment capacities, extraction well uranium concentrations, and treatment effluent concentrations. Table 5.1 is the output from the Testpump spreadsheet that predicts an outfall concentration of approximately 26 µg/L during CAWWT construction.

Verification that capture of the 30 µg/L uranium plume is being maintained was determined by measuring water levels, constructing water table map(s), interpreting flow directions and capture from the map(s), and adjusting pumping rates (if needed) to achieve the best available capture. The procedure is outlined below.

- Water level transducers and data loggers will be installed 2 days prior to the shutdown of the re-injection wells in Monitoring Wells 22299, 22300, 22301, 22302, 22303 and 23279. Figure 5.1 shows the locations of these wells. These wells are located along Willey Road next to the original five re-injection wells (IW-8, IW-9, IW-10, IW-11, and IW-12). Transducers will monitor the resulting fall in water levels along Willey Road and provide a "tight look" at how much water-level fall occurred and an indication of when the fall has stabilized.
- Well-based re-injection will be stopped, and the pumping rates modeled for Approach C during the CAWWT construction time period will be implemented. This is the time period where pumping rates will probably be the lowest due to the low treatment capacity of 700 gpm available for groundwater. Table 2.1.1 indicates lower pumping rates in pumping period three, but in

the entire SSOD when remediation activities in the northwestern branch of the SSOD are complete. It is possible that both branches of the SSOD may need to be used in order to achieve an infiltration rate of 500 gpm.

The baseline 500 gpm test in the northeastern branch of the SSOD will be conducted in the late fall of 2004 or early winter 2005. A 500 gpm flow of clean water into the SSOD will need to be established and maintained for the test, and a means of measuring discharge into and out of the SSOD will also be needed. The set-up requirements and procedure are presented below.

Set-Up

A temporary line (6-inch flexible diameter hose) will be used to convey pumped groundwater from Construction Well 42202 to a discharge point in the northeastern fork of the SSOD. A flow meter will be installed at the discharge point that is capable of measuring flows accurately up to **1000 gpm**. The northwestern fork of the SSOD begins between the Storm Water Retention Basins and contains soil and sediment FRL exceedances, so discharge into it will be avoided for this test.

Weirs will be installed for the purpose of measuring flow rates. A rectangular Weir with end contractions will be installed in the SSOD at the entrance to the culvert that runs beneath the road just south of the former Active Flyash Pile area, (Figure 3.1). A Weir large enough to measure a 500-gpm flow can be installed in this area without causing any flooding over the bank of the SSOD. Following calculations presented in Driscoll (1976), a 5-foot long Weir with a head rise of 2 inches, equates to a flow of approximately 500 gpm (Table 5.2). Additional small Weirs will be installed at locations where smaller tributaries enter the main channel of the SSOD. Although they may pond water a little bit, their main intent is not to pond water in the SSOD. Later testing may be conducted that involves the ponding of water.

Procedure

The overall approach will be to first determine if the SSOD can be used as a recharge source for the GMA at a rate of 500 gpm. If this capability is verified, extraction well pumping rates will be changed to match the pumping rates modeled for the third pumping period of Approach C-Improved, (Table 3.1.1). Capture of the 30 µg/L uranium plume will then be verified in the field using the approach used in Part I of this verification plan.

- With extraction well pumping rates set at the pumping rates established for capture in Part I above, discharge will be initiated into the SSOD at a flow rate of 500 gpm. Water level at the Weir will be monitored and a discharge rate calculated to determine how much (if any) of the 500 gpm flow failed to infiltrate the base of the SSOD and continues to move through the SSOD towards Paddys Run. Flow rates at the Weir will be monitored until the flow has equilibrated. Flow through the Weir will be calculated using methods described in Driscoll (1986). If 500 gpm of induced recharge in the SSOD cannot be verified, then the operation will be terminated.

- If the SSOD is capable of sustaining a recharge rate of 500 gpm to the GMA, then pumping rates will be adjusted to match those of Pumping Period 3 of Modeling Approach C-Improved (Table 3.1.1). Table 5.3 is the output from the Testpump spreadsheet that predicts an outfall concentration of approximately 30.6 µg/L during this testing period. Capture of the 30 µg/L uranium plume will be verified using the same approach presented in Part I.

- After water levels have been allowed to stabilize to the new pumping rates for two days, water levels will be measured in all IEMP water level monitoring wells. This task will be coordinated with routine IEMP water level measurement activities if possible.

- A water level map will be constructed using the collected water level measurements. Capture and flow interpretations will be made from the mapped data to determine if capture of the 30 µg/L uranium plume is being achieved.

- If capture interpretations indicate that capture is not being achieved, then pumping rates will be changed in an effort to achieve the best plume capture possible. The first objective will be to achieve the best possible capture of the on-property 30 µg/L uranium plume. The second objective will be to achieve the best capture possible of the overall 30 µg/L uranium plume. If pumping rate changes are made, the aquifer will be given two days to adjust before additional water-level measurements are collected and capture-zone interpretations are made. Individual well pumping rates defined for the CAWWT construction period are well below the maximum individual pumping rates that could be achieved. Discharge limits at the Parshall Flume will determine how high pumping rates can be adjusted.

If capture of the 30 µg/L uranium plume cannot be verified in all areas using water level measurements, the use of the colloidal boroscope and tracers in those areas will also be considered. Flow direction measurements using the colloidal boroscope would be attempted first; if they are inconclusive the use of tracers will be considered. Tracers would only be used with the approval of EPA and OEPA.

Once best capture has been verified and pumping rates for the best capture have been determined, a decision will be made to either continue with the SSOD operation or to return the system to pumping rates defined in Part I above.

Activity 2 - Gauging of seasonal flows of water in the SSOD to gain a better understanding of how much of the seasonal flow infiltrates into the bed of the SSOD

By having Weirs installed at each of the tributaries leading into the SSOD, as well as at the exit point of the SSOD as it goes through the culvert beneath the south Field Access Road, it will be possible to measure and record flow rates due to seasonal flow activity also. Weirs will be installed with a means of measuring the difference in height between the crest of the Weirs and the surface of the flowing water 3 to 8 feet upstream of the crest of the Weirs. Measuring this far back will eliminate the effect of the increase in velocity as the water spills over the crest of the Weirs. It is anticipated that each Weir will be equipped with a water level transducer and data logger in order to determine and record water level heights relative to the crest of the Weir. Data loggers will be set to record hourly elevation readings.

Activity 3 - Installation of infiltrometers at select locations along the bed of the SSOD

This activity is envisioned as a precursor to additional future flow testing. If the 500-gpm baseline test is successful, future testing will be conducted at higher flow rates to determine a maximum flow rate for long-term operations. A better estimate of infiltration rates into the bottom sediments of the SSOD will aid in establishing an upper flow rate for the future test. The objective for installing infiltrometers at select locations in the SSOD would therefore be to determine infiltration rates through the bottom sediments of the SSOD and to estimate a hydraulic conductivity for the bottom sediments of the SSOD.

Activity 4 - Future flow testing

Future flow testing would utilize the entire SSOD (both northwestern and northeastern branches) once SSOD remediation activities are complete to establish an optimal long-term flow rate for enhancing recharge to the GMA. The procedure followed for the test would be similar to the procedure followed for the baseline 500-gpm flow test.

Table 5.1
Test Pump Output for CAWWT Construction Period Water Treatment Systems

700

System Effluent Conc.	
System ID	Effluent Concentration (ppb)
AWWT/P1	10
AWWT/P2	10
IAWWT/T108	5
IAWWT/T109	5
AWWT/EXP	0
SPIT	2
STP	0

Treatment Excess (gpm)
0

Remediation Water	
System ID	Capacity (gpm)
AWWT/P1	300
AWWT/P2	0

Storm Water	
System ID	Capacity (gpm)
AWWT/P1	0
AWWT/P2	300
IAWWT/T108	0
IAWWT/T109	0

Sanitary Water	
System ID	Capacity (gpm)
STP	0

Groundwater	
System ID	Capacity (gpm)
AWWT/EXP	0
SPIT	200
IAWWT/T108	300
IAWWT/T109	0
AWWT/P1	200
AWWT/P2	0

Injection Water	
Capacity (gpm)	Concentration (ppb)
0	0

Net Treatment Effluent	
Flow Rate (gpm)	Concentration (ppb)
1300	7.6

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Table 5.1 (continued)
Test Pump Output for CAWWT Construction Period
Well Field Systems

South Plume Extraction System Well ID	Pumping Rate (gpm)	Total U Concentration (ppb)
RW-1	300	23.0
RW-2	300	23.9
RW-3	300	29.3
RW-4	400	3.4
RW-6	300	43.1
RW-7	300	45.4
S. Plume	1900	26.7

South Field Extraction System Well ID	Pumping Rate (gpm)	Total U Concentration (ppb)
EW 15A	100	57.9
EW 17	275	27.0
EW 18	200	47.6
EW 19	200	44.0
EW 20	200	34.2
EW 21	100	52.6
EW 22	300	63.5
EW 23	300	81.6
EW 24	100	57.7
EW 25	300	47.0
EW 30	100	62.3
EW 31	300	27.5
EW 32	200	10.8
S. Field	2675	46.2

Re-Injection Systems Well ID	Injection Rate (gpm)	Total U Concentration (ppb)
IW 8A	0	0.0
IW 9A	0	0.0
IW 10	0	0.0
IW 10A	0	0.0
IW 11	0	0.0
IW 12	0	0.0
IW 16	0	0.0
IW 20	0	0.0
Basins	0	0.0
S. Field	0	0.0

Waste Storage Area/Pilot Plant Draingage Ditch System Well ID	Pumping Rate (gpm)	Total U Concentration (ppb)
EW 26	0	45.0
EW 27	0	48.0
EW 28	0	20.0
5	0	0.0
6	0	0.0
WSA/PPDD	0	0.0

Sorted Well List	T=Treat S = Split B = Bypass X = Not Pumping	Groundwater to Treatment	Groundwater to Bypass
EW 23	T	300	0
EW 22	T	300	0
EW 30	T	100	0
EW 15A	B	0	100
EW 24	B	0	100
EW 21	B	0	100
EW 27	X	0	0
EW 18	B	0	200
EW 25	B	0	300
EW 26	X	0	0
EW 19	B	0	200
EW 20	B	0	200
EW 31	B	0	300
EW 17	B	0	275
S. Plume	B	0	1900
EW 28	X	0	0
EW 32	B	0	200
5	X	0	0
6	X	0	0

Groundwater to Treatment (gpm)	Concentration to Treatment (ppb)
700	71.1

Total Pumping All Systems (gpm)	Total Injection All Systems (gpm)	Net Pumping (Extraction - Injection) (gpm)
4575	0	4575

Groundwater to Bypass (gpm)	Concentration to Bypass (gpm)
3875	32.2

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Table 5.1 (continued)
Test Pump Output for CAWWT Construction Period
Concentration Summary

Net Treatment Effluent			
Component	Flow Rate (gpm)	Concentration (ppb)	Mass per Day (lbs)
Net Treated	1300	7.6	0.12
Excess	0	71.1	0.00

Groundwater to Bypass		
Flow Rate (gpm)	Concentration (ppb)	Mass per Day (lbs)
3875	32.2	1.49

Outfall			
Flow Rate (gpm)	Concentration ppb	Mass per Day (lbs)	Mass per Yr (lbs)
5175	26.0	1.61	589

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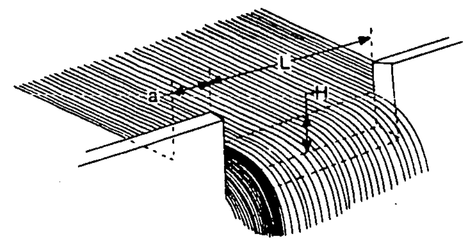
57 4'3

Table 5.2

Discharge from Rectangular Weir with End Contractions



Figures in Table are in Gallons Per Minute								
	Length (L) of weir in feet					Length (L) of weir in feet		
Head (H) in inches	1	3	5	Additional gpm for each ft over 5 ft	Head (H) in inches	3	5	Additional gpm for each ft over 5 ft
1	35.4	107.5	179.8	36.05	8	2338	3956	814
1¼	49.5	150.4	250.4	50.4	8¼	2442	4140	850
1½	64.9	197	329.5	66.2	8½	2540	4312	890
1¾	81	248	415	83.5	8¾	2656	4511	929
2	98.5	302	506	102	9	2765	4699	970
2¼	117	361	605	122	9¼	2876	4899	1011
2½	136.2	422	706	143	9½	2985	5098	1051
2¾	157	485	815	165	9¾	3101	5288	1091
3	177.8	552	926	187	10	3216	5490	1136
3¼	199.8	624	1047	211	10½	3480	5940	1230
3½	222	695	1167	236	11	3716	6355	1320
3¾	245	769	1292	261	11½	3960	6780	1410
4	[illegible]	846	1424	288	12	4185	7165	1495
4¼	[illegible]	925	1559	316	12½	4430	7595	1575
4½	318	1006	1696	345	13	4660	8010	1660
4¾	344	1091	1835	374	13½	4950	8510	1780
5	370	1175	1985	405	14	5215	8980	1885
5¼	395.5	1262	2130	434	14½	5475	9440	1985
5½	421.6	1352	2282	465	15	5740	9920	2090
5¾	449	1442	2440	495	15½	6015	10400	2165
6	476.5	1535	2600	528	16	6290	10900	2300
6¼		1632	2760	560	16½	6565	11380	2410
6½		1742	2920	596	17	6925	11970	2520
6¾		1826	3094	630	17½	7140	12410	2640
7		1928	3260	668	18	7410	12900	2745
7¼		2029	3436	701.5	18½	7695	13410	2855
7½		2130	3609	736	19	7980	13940	2970
7¾		2238	3785	774	19½	8280	14460	3090

From Groundwater and Wells, Second Editions, 1986, Published by Johnson Division, St. Paul, Minesota

Table 5.3
Test Pump Output during SSOD Test
Approach C-Improved Pumping Rates (4/1/05 to 4/1/06)
Water Treatment Systems

700

System Effluent Conc.

System ID	Effluent Concentration (ppb)
AWWT/P1	10
AWWT/P2	10
IAWWT/T108	5
IAWWT/T109	5
AWWT/EXP	0
SPIT	2
STP	0

Remediation Water

System ID	Capacity (gpm)
AWWT/P1	300
AWWT/P2	0

Injection Water

Capacity (gpm)	Concentration (ppb)
0	0

Storm Water

System ID	Capacity (gpm)
AWWT/P1	0
AWWT/P2	300
IAWWT/T108	0
IAWWT/T109	0

Net Treatment Effluent

Flow Rate (gpm)	Concentration (ppb)
1300	7.6

Treatment Excess

(gpm)
0

Sanitary Water

System ID	Capacity (gpm)
STP	0

Groundwater

System ID	Capacity (gpm)
AWWT/EXP	0
SPIT	200
IAWWT/T108	300
IAWWT/T109	0
AWWT/P1	200
AWWT/P2	0

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Table 5.3 (continued)
Test Pump Output during SSOD Test
Approach C-Improved Pumping Rates (4/1/05 to 4/1/06)
Well Field Systems

South Plume Extraction System

Well ID	Pumping Rate (gpm)	Total U Concentration (ppb)
RW-1	200	23.0
RW-2	200	23.9
RW-3	200	29.3
RW-4	400	3.4
RW-6	200	43.1
RW-7	200	45.4
S. Plume	1400	24.5

South Field Extraction System

Well ID	Pumping Rate (gpm)	Total U Concentration (ppb)
EW 15A	200	57.9
EW 17	175	27.0
EW 18	100	47.6
EW 19	100	44.0
EW 20	100	34.2
EW 21	200	52.6
EW 22	300	63.5
EW 23	300	81.6
EW 24	300	57.7
EW 25	400	47.0
EW 30	400	62.3
EW 31	400	27.5
EW 32	400	10.8
S. Field	3375	47.2

Re-Injection Systems

Well ID	Injection Rate (gpm)	Total U Concentration (ppb)
IW 8A	0	0.0
IW 9A	0	0.0
IW 10	0	0.0
IW 10A	0	0.0
IW 11	0	0.0
IW 12	0	0.0
IW 16	0	0.0
IW 20	0	0.0
Basins	0	0.0
S. Field	0	0.0

Waste Storage Area/Pilot Plant Draingage Ditch System

Well ID	Pumping Rate (gpm)	Total U Concentration (ppb)
EW 26	300	45.0
EW 27	200	48.0
EW 28	0	20.0
5	0	0.0
6	0	0.0
WSA/PPDD	500	46.2

Sorted Well List	T=Treat S = Split B = Bypass X = Not Pumping	Groundwater to Treatment	Groundwater to Bypass
EW 23	T	300	0
EW 22	T	300	0
EW 30	B	0	400
EW 15A	B	0	200
EW 24	B	0	300
EW 21	B	0	200
EW 27	B	0	200
EW 18	B	0	100
EW 25	B	0	400
EW 26	B	0	300
EW 19	B	0	100
EW 20	B	0	100
EW 31	B	0	400
EW 17	B	0	175
S. Plume	B	0	1400
EW 28	X	0	0
EW 32	B	0	400
5	X	0	0
6	X	0	0

Groundwater to Treatment (gpm)	Concentration to Treatment (ppb)
600	72.6

Total Pumping All Systems (gpm)	Total Injection All Systems (gpm)	Net Pumping (Extraction - Injection) (gpm)
5275	0	5275

Groundwater to Bypass (gpm)	Concentration to Bypass (gpm)
4675	37.0

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Table 5.3 (continued)
Test Pump Output during SSOD Test
Approach C-Improved Pumping Rates (4/1/05 to 4/1/06)
Concentration Summary

Net Treatment Effluent			
Component	Flow Rate (gpm)	Concentration (ppb)	Mass per Day (lbs)
Net Treated	1300	7.6	0.12
Excess	0	72.6	0.00

Groundwater to Bypass		
Flow Rate (gpm)	Concentration (ppb)	Mass per Day (lbs)
4675	37.0	2.08

Outfall			
Flow Rate (gpm)	Concentration ppb	Mass per Day (lbs)	Mass per Yr (lbs)
5975	30.6	2.19	802

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Table 5.4
Water Level Change Resulting from the Stop of Re-Injection

Injection Well	Monitoring Well	Elevation Feet (amsl) 09/24/2004 18:00 hours	Elevation Feet (amsl) 09/25/2004 18:00 hours	24 hour Elevation Change (feet)	Elevation Feet (amsl) 09/26/2004 18:00 hours	48 hour Elevation Change (feet)
IW-8	22299	514.982	514.727	-0.255	514.686	-0.296
IW-9	22300	515.918	515.542	-0.376	515.556	-0.362
IW-10	22301	515.626	514.681	-0.945	514.767	-0.859
IW-11	22302	514.599	514.145	-0.454	514.311	-0.288
IW-12	22303	514.015	514.128	0.113	514.315	0.300
IW-29	23279	515.721	515.820	0.099	515.980	0.259

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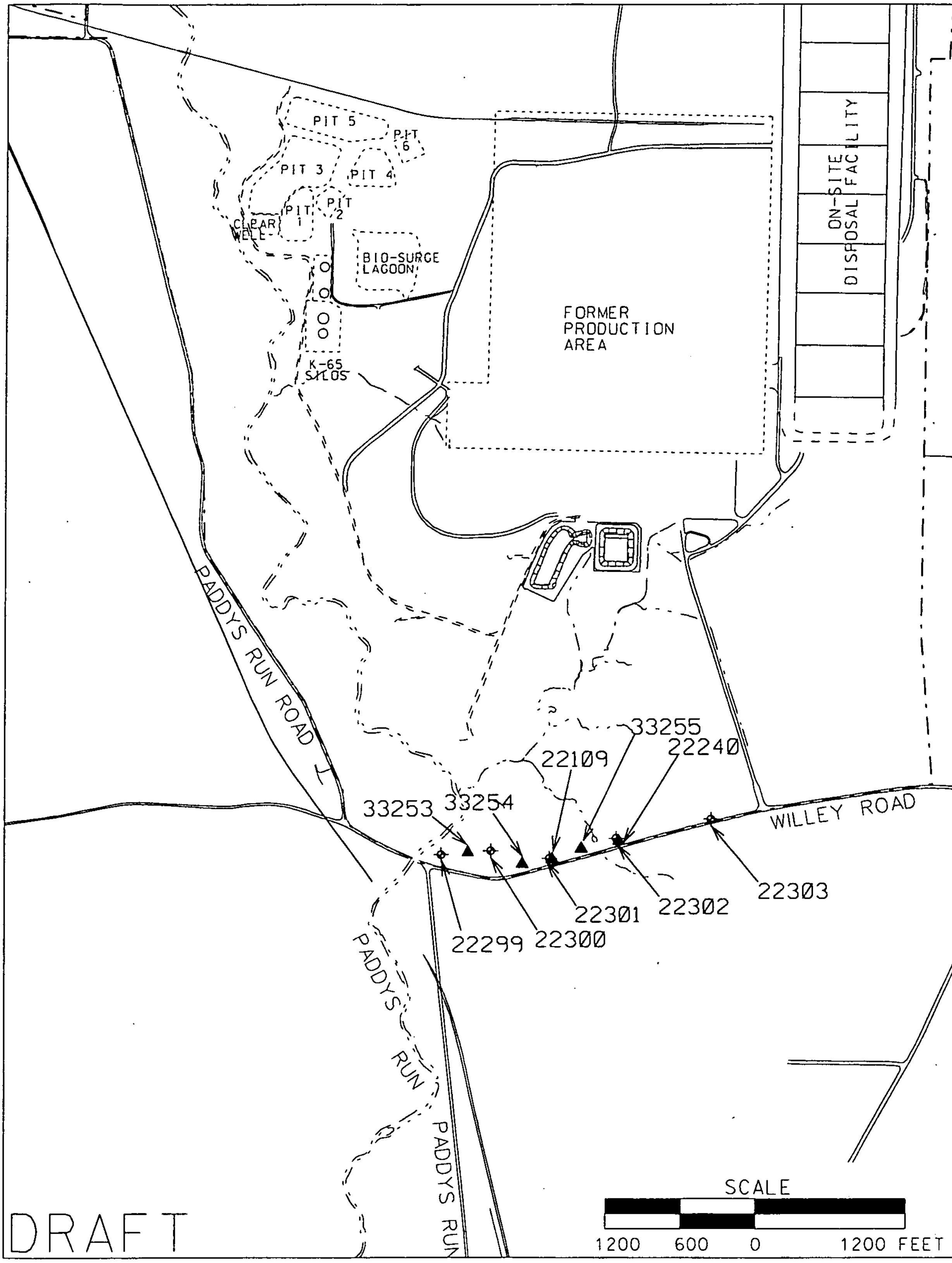

LEGEND:

— · — · — FERNALD SITE BOUNDARY

▲ RE-INJECTION WELL

EXTRACTION WELL

MONITORING WELL

FIGURE 5.1. LOCATION MAP FOR PART-1 FIELD VERIFICATION

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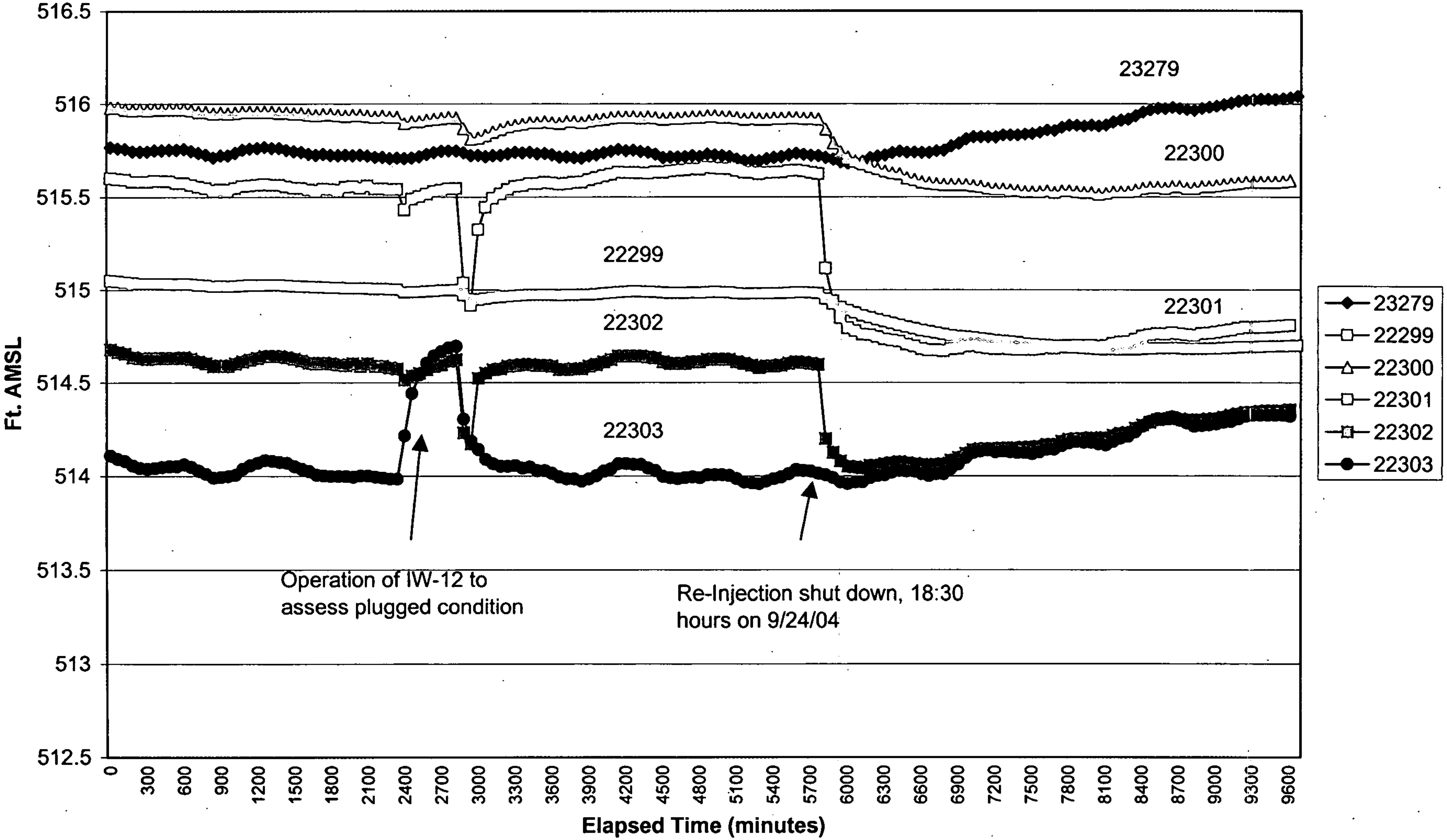
STATE PLANAR COORDINATE SYSTEM 1983

24-JUN-2004

Figure 5.2
Change in Water Level when Re-Injection was shut down at 18:30 hours on 9/24/04



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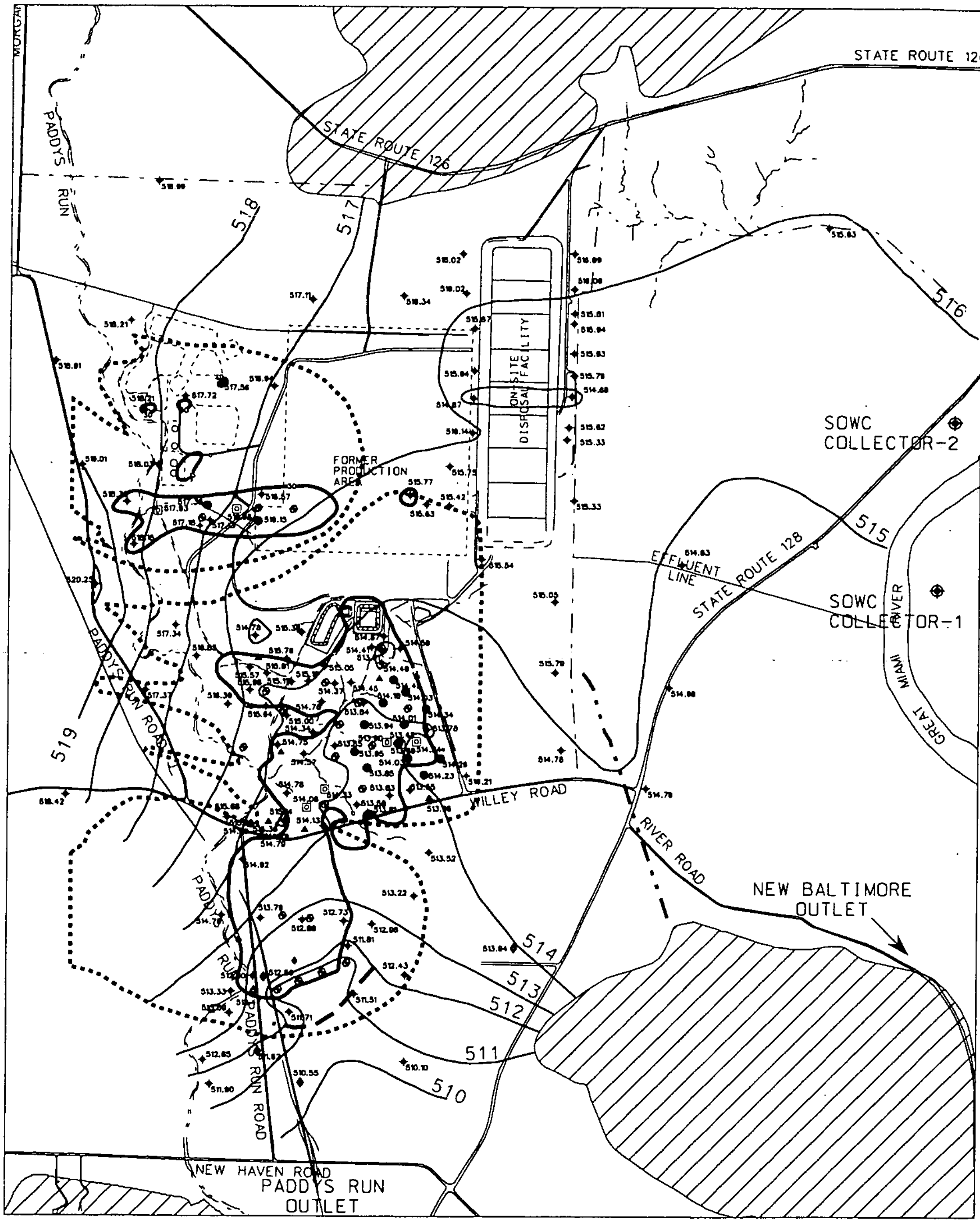

LEGEND:

- FCP SITE BOUNDARY
- GROUNDWATER ELEVATION CONTOUR (FEET AMSL)
- CAPTURE ZONE
- BEDROCK HIGHS
- 10-YEAR, TIME-OF-TRAVEL REMEDIATION FOOTPRINT
- APPROXIMATE LOCATION OF GROUNDWATER FLOW DIVIDE
- 516.22 GROUNDWATER ELEVATION (FEET AMSL)
- EXTRACTION WELL
- INJECTION WELL
- EXTENT OF THE MAXIMUM TOTAL URANIUM 30 µg/L CONTOUR FROM BRSR, MODIFIED AS NEEDED THROUGH SECOND HALF 2003

OCTOBER 4 THROUGH 6, 2004 OPERATIONAL STATUS:	ACTUAL PUMPING/ RE-INJECTION RATES (gpm)
SOUTH PLUME: 5 WELLS	1,600
RE-INJECTION: 0 WELLS	0
SOUTH FIELD EXTRACTION: 13 WELLS	2,580
WASTE STORAGE AREA: 0 WELLS	0

SCALE

1300 650 0 1300 FEET

27-OCT-2004

DRAFT

FIGURE 5.3. GROUNDWATER ELEVATION MAP (OCTOBER 4 THROUGH 6, 2004)

REFERENCES

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Monitoring Wells 23279 and 22303 appear to have been unaffected by the stop of re-injection. The reason is attributed to the wells being too far away from the active re-injection wells that were shut off, even though they were the closest available wells for monitoring.

Figure 5.3 is the water level map that was produced from water level data collected beginning two days subsequent to the pumping rate change being implemented. Water level measurements were collected from October 4, 2004 to October 6, 2004 and also served to satisfy collection of the fourth quarter 2004 IEMP water level measurements. Waiting two days for the collection of water elevation measurements following re-establishment of pumping rates, allowed the aquifer to adjust to the new operating conditions. Water table contours in Figure 5.3 indicate that flow is in the direction needed to maintain capture of the 30 µg/L uranium plume. No pumping is currently taking place in the Waste Storage Area. Additional work is in progress to assess plume capture using well triad mapping techniques. Results will be shared with the EPAs when they are available. This latest capture interpretation is made at a net system-pumping rate of 4,180 gpm.

Part II - Determining Infiltration Capabilities of the SSOD

<u>Activity 1 - Enhancing recharge using a flow rate of 500 gpm</u>

The groundwater model predicts that if well-based re-injection is stopped, and 500 gpm of clean water is pumped into the SSOD and allowed to recharge into the aquifer, that the remedy would be shortened by one year and capture of the 30 µg/L uranium plume will be maintained. Flow model results also indicate that pumping Construction Well 42202 to provide 500 gpm for infiltration down the SSOD does not detrimentally affect plume gradients and flow patterns associated with the aquifer remedy. Part II focuses on verifying these predictions and determining if induced infiltration down the SSOD at a rate of 500 gpm is feasible. Demonstrating capture of the 30 µg/L uranium plume will also verify the model prediction that the pumping of Construction Well 42202 does not affect capture.

The SSOD consists of a northwestern branch and a northeastern branch. The northeastern branch is clean, but the northwestern branch contains soil and sediment final remediation level (FRL) exceedances. The northwestern branch will not be remediated until late 2005, so testing of the infiltration capability of the SSOD can proceed only in the clean northeastern branch of the SSOD. If it is determined that the SSOD can be used to recharge the aquifer at a rate of 500 gpm, recharge operations could be continued, making the beneficial impact to the aquifer remedy immediate. An unsuccessful test in the northeastern branch of the SSOD at a flow rate of 500 gpm will however not be considered conclusive evidence to discard this operational strategy. If unsuccessful in the northeastern branch, additional testing will be conducted in reality pumping is expected to be higher during this time period because groundwater treatment capacity will be 1200+ gpm rather than 800 gpm following construction of the CAWWT

- After water levels have been allowed to stabilize to the new pumping rates for two days, water levels will be measured in all IEMP water level monitoring wells. This task will be coordinated with routine IEMP water level measurement activities if possible.

- A water level map will be constructed using the collected water level measurements. Capture and flow interpretations will be made from the mapped data to determine if capture of the 30 μg/L uranium plume is being achieved. Analysis will include well triad interpretations.

- If capture interpretations indicate that capture is not being achieved, then pumping rates will be changed in an effort to achieve the best plume capture possible. The first objective will be to achieve the best possible capture of the on-property 30 μg/L uranium plume. The second objective will then be to achieve the best capture possible of the overall 30 μg/L uranium plume. If any pumping rate changes are made, the aquifer will be given two days to adjust before additional water level measurements are collected and capture-zone interpretations are made.

- Individual well pumping rates defined for the CAWWT construction period are well below the maximum individual pumping rates that could be achieved, with the exception of SF-17. This well is not performing as well as it has in the past and is only able to maintain a pumping rate of 180 gpm.

- Once best capture has been verified and pumping rates for the best capture have been determined, the system will continue to operate using these rates, unless there is a problem with meeting the discharge limits at the Parshall Flume. Meeting discharge limits at the Parshall Flume will take precedence over maintaining target pumping rates or plume capture.

If capture of the 30 μg/L uranium plume cannot be verified in all areas using water-level measurements the use of the colloidal boroscope and tracers in those areas will also be considered. Flow direction measurements using the colloidal boroscope would be attempted first; if they are inconclusive the use of tracers would be considered. Tracers would only be used with the approval of EPA and OEPA.

Results for Part I

All pumping and re-injection was stopped on September 24, 2004 at 18:30 hours to facilitate the start of converting the AWWT into the CAWWT. Pumping wells were restarted in a phased approach the following week and by October 1, 2004 pumping rates defined for the CAWWT construction time period (Pumping Period 2 in Tables 2.1.1 and 3.1.1) were achieved with the exception of Wells RW-7 and SF-17. RW-7 was not operating due to maintenance problems, and SF-17 was only operating at a set point of 180 gpm instead of 275 gpm. Figure 5.2 illustrates the drop in water levels recorded by the transducers installed in Monitoring Wells 22299, 22300, 22301, 22302, 22303, and 23279. The range of water level change recorded in the first 48 hours after re-injection was stopped is presented in Table 5.4. The largest change after 24 hours (-0.945 feet) was recorded in Monitoring Well 22301 (next to IW-10).